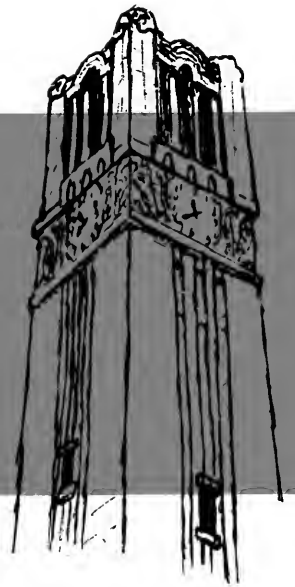


THE GRADUATE SCHOOL

1960-1962

NORTH CAROLINA
STATE COLLEGE



STATE COLLEGE RECORD

Vol. 59, No. 5, January, 1960

Published monthly by the North Carolina State College of Agriculture and Engineering. Entered as Second-Class Matter October 16, 1917, at the Post Office at Raleigh, N. C., Under the Act of August 24, 1912.

THE GRADUATE SCHOOL CATALOG

1960-1962

NORTH CAROLINA STATE COLLEGE

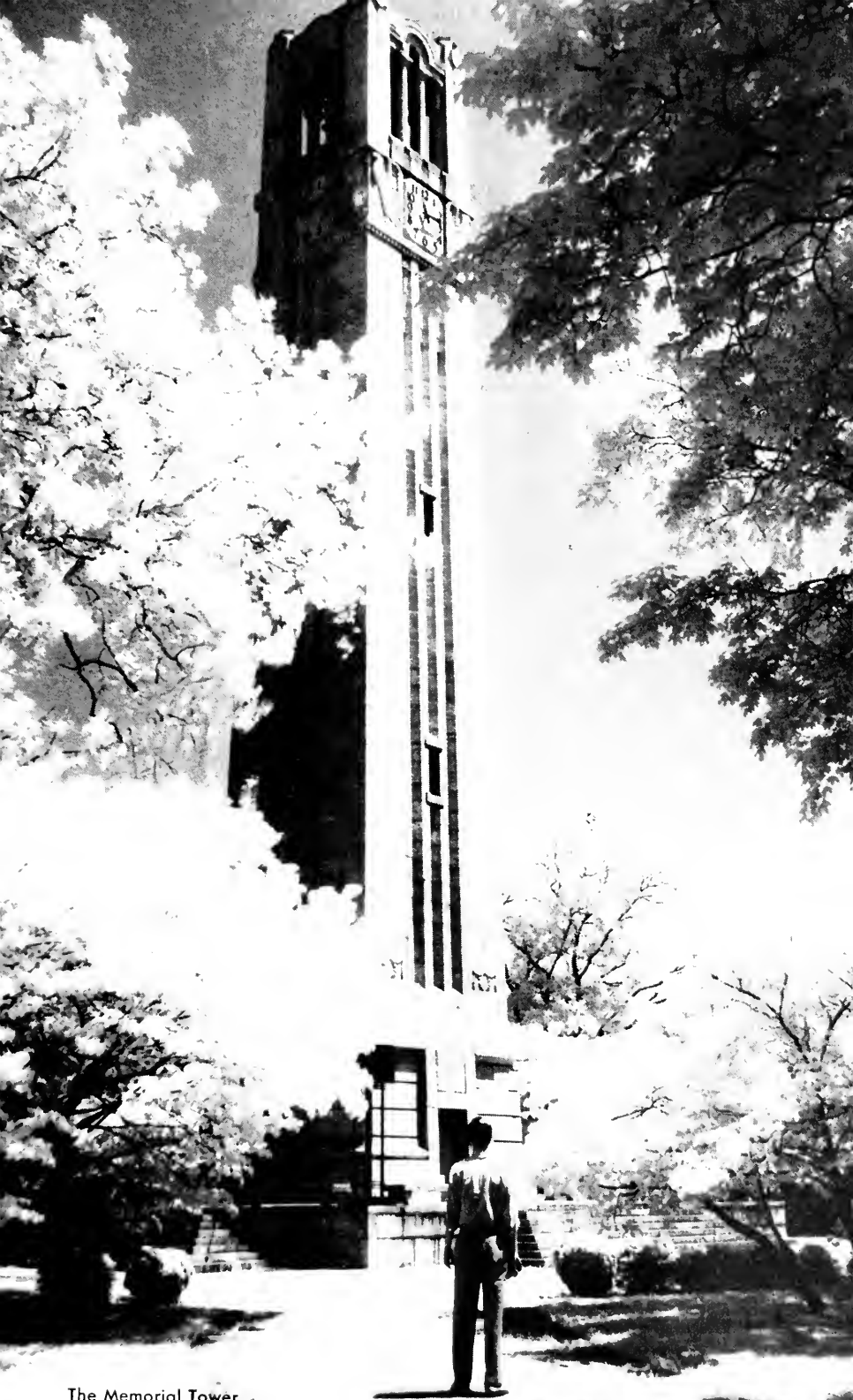
RALEIGH, NORTH CAROLINA

THE GRADUATE SCHOOL CATALOG

1960-1962

NORTH CAROLINA STATE COLLEGE
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The Student Union

*THE COLLEGE CALENDAR

Summer Sessions 1960 First Session

June 14	Tues.	Registration. Late registration fee of \$5.00 payable by all who register after June 14.
June 15	Wed.	First day of classes.
June 20	Mon.	Last day for registration. Last day to withdraw with refund and last day to drop any course with refund.
June 24	Fri.	Last day to drop courses without failure and last day to withdraw without failure.
June 30	Thurs.	<i>Last day for accepting theses for candidates for the master's and doctoral degrees in July.</i>
July 4	Mon.	Holiday
July 14	Thurs.	<i>Last day for taking final oral examination for candidates for the master's and doctoral degrees in July.</i>
July 20	Wed.	Last day of classes.
July 21	Thurs.	Final examinations.

Second Session

July 22	Fri.	Registration. Late registration fee of \$5.00 payable by all registering after July 22.
July 25	Mon.	First day of classes.
July 29	Fri.	Last day for registration. Last day to withdraw with refund and last day to drop any course with refund.
August 3	Wed.	Last day to drop a course without failure and last day to withdraw without failure.
August 5	Fri.	<i>Last day for accepting theses for candidates for the master's and doctoral degrees in August.</i>
August 19	Fri.	<i>Last day for taking final oral examination for candidates for the master's and doctoral degrees in August.</i>
August 25	Thurs.	Last day of classes.
August 26	Fri.	Final examinations.

Fall Semester 1960

September 16	Fri.	Registration. Late registration fee of \$5.00 payable by all who register after September 16.
September 19	Mon.	Classes begin 8:00 a.m.
September 23	Fri.	Last day for registration. Last day for refund less \$5.00 registration fee. <i>Last day for filing application for admission to candidacy for students expecting to complete requirements for the master's degree in January.</i>
September 30	Fri.	Last day to add a course.

*Applications for admission to the Graduate School, accompanied by full credentials in the form of transcripts of academic records, should be filed in the office of the Graduate Dean at least thirty days in advance of the semester in which admission is sought.

October 7	Fri.	Last day to drop a course without failure. <i>Last day for taking qualifying examinations for students expecting to receive doctorate in May.</i>
November 7	Mon.	<i>Meeting of the Graduate Executive Council of the Consolidated University.</i>
November 12	Sat.	Mid-term reports.
November 23	Wed.	Thanksgiving holidays begin at 1:00 p.m.
November 28	Mon.	Classwork resumes 8:00 a.m.
November 29	Tues.	Last day to withdraw from school without failures.
December 17	Sat.	Christmas holidays begin at 12:00 noon.
December 19	Mon.	<i>Last day for accepting theses for candidates for the Ph.D. degree in January.</i>
January 2, 1961	Mon.	<i>Last day for accepting theses for candidates for the master's degree in January.</i>
January 3	Tues.	Classwork resumes 8:00 a.m.
January 16	Mon.	<i>Last day for taking final oral examinations for candidates for the master's degree in January.</i>
January 21	Sat.	Last day of classes.
January 23	Mon.	<i>Last day for taking final oral examinations for candidates for the Ph.D. degree in January.</i>
January 23-28	Mon.-Sat.	Final examinations.
January 30	Mon.	Awarding of degrees for graduating students.

Spring Semester 1961

February 3	Fri.	Registration. Late registration fee of \$5.00 payable by all who register after February 3.
February 6	Mon.	Classes begin 8:00 a.m.
February 10	Fri.	Last day to register. Last day for refund less \$5.00 registration fee. <i>Last day for filing application for admission to candidacy for students expecting to complete requirements for the master's degree in May.</i>
February 17	Fri.	Last day to add a course.
February 24	Fri.	Last day to drop a course without failure. <i>Last day for taking qualifying examinations for students expecting to receive doctorate in August.</i>
March 25	Sat.	Mid-term reports.
March 29	Wed.	Easter holidays begin at 6:00 p.m.
April 3	Mon.	<i>Meeting of the Graduate Executive Council of the Consolidated University.</i>
April 6	Thurs.	Classwork resumes 7:45 a.m.
April 8	Sat.	Last day for withdrawing from school without failures.
April 17	Mon.	<i>Last day for accepting theses for candidates for the Ph.D. degree in May.</i>
May 1	Mon.	<i>Last day for accepting theses for candidates for the master's degree in May.</i>

May 13	Sat.	<i>Last day for taking final oral examinations for candidates for the master's degree in May.</i>
May 20	Sat.	<i>Last day for taking final oral examinations for candidates for the Ph.D. degree in May.</i>
May 27	Sat.	Last day of classes.
May 28	Sun.	Commencement.
May 29-June 3	Mon.-Sat.	Final examinations.

Fall Semester
(tentative calendar)
1961

September 15	Fri.	Registration. Late registration fee of \$5.00 payable by all who register after September 15.
September 18	Mon.	Classes begin 8:00 a.m.
September 22	Fri.	Last day for registration. Last day for refund less \$5.00 registration fee. <i>Last day for filing application for admission to candidacy for students expecting to complete requirements for the master's degree in January.</i>
September 29	Fri.	Last day to add a course.
October 6	Fri.	Last day to drop a course without failure. <i>Last day for taking qualifying examinations for students expecting to receive doctorate in May.</i>
November 6	Mon.	<i>Meeting of the Graduate Executive Council of the Consolidated University.</i>
November 11	Sat.	Mid-term reports.
November 22	Wed.	Thanksgiving holiday begins 1:00 p.m.
November 27	Mon.	Classwork resumes 8:00 a.m.
November 28	Tues.	Last day to withdraw from school without failures.
December 16	Sat.	Christmas holidays begin at 12:00 noon.
December 18	Mon.	<i>Last day for accepting theses for candidates for the Ph.D. degree in January.</i>
January 2, 1962	Tues.	Classwork resumes 8:00 a.m. <i>Last day for accepting theses for candidates for the master's degree in January.</i>
January 15	Mon.	<i>Last day for taking final oral examinations for candidates for the master's degree in January.</i>
January 20	Sat.	Last day of classes.
January 22	Mon.	<i>Last day for taking final oral examinations for candidates for the Ph.D. degree in January.</i>
January 22-27	Mon.-Sat.	Final examinations.
January 29	Mon.	Awarding of degrees for graduating students.

Spring Semester
(tentative calendar)
1962

February 2	Fri.	Registration. Late registration fee of \$5.00 payable by all who register after February 2.
February 5	Mon.	Classes begin 8:00 a.m.

February 9	Fri.	Last day to register. Last day for refund less \$5.00 registration fee. <i>Last day for filing application for admission to candidacy for students expecting to complete requirements for the master's degree in May.</i>
February 16	Fri.	Last day to add a course.
February 23	Fri.	Last day to drop a course without failure. <i>Last day for taking qualifying examinations for students expecting to receive doctorate in August.</i>
March 24	Sat.	Mid-term reports.
April 2	Mon.	<i>Meeting of the Graduate Executive Council of the Consolidated University.</i>
April 6	Sat.	Last day for withdrawing from school without failures.
April 16	Mon.	<i>Last day for accepting theses for candidates for the Ph.D. degree in May.</i>
April 18	Wed.	Easter holiday begins at 6:00 p.m.
April 26	Thurs.	Classwork resumes 7:45 a.m.
April 30	Mon.	<i>Last day for accepting theses for candidates for the master's degree in May.</i>
May 12	Sat.	<i>Last day for taking final oral examinations for candidates for the master's degree in May.</i>
May 19	Sat.	<i>Last day for taking final oral examinations for candidates for the Ph.D. degree in May.</i>
May 26	Sat.	Last day of classes.
May 27	Sun.	Commencement
May 28-June 2	Mon-Sat.	Final examinations.

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The Executive Council is made up of the members of the Advisory Boards of each of the three units of the Consolidated University. The President, the Vice-Presidents, the Chancellors and the Graduate Deans are ex-officio members of the Executive Council.

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at

NORTH CAROLINA STATE COLLEGE

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*Membership in the graduate faculty may be in either of two categories: (1) Full status or (2) Associate status. Full status permits a faculty member to engage in any and all phases of the graduate programs of the college. Associate members may teach courses at the graduate level and participate in the planning of graduate student programs. They may not serve as chairmen of advisory committees or assume responsibility for the direction of the research studies of graduate students.

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Ph.D., Rutgers University.
- Richard Bennett Knight, Professor of Mechanical Engineering.
M.S., University of Illinois.
- Ken-ichi Kojima, Assistant Professor of Genetics.
Ph.D., N. C. State College.
- William Wurth Kriegel, Professor in charge of Ceramic Engineering.
Dr. Ing., Technische Hochschule, Hanover, Germany.
- Walter Michael Kulash, Professor of Entomology.
Ph.D., Massachusetts State College.
- Arthur Irish Ladu, Professor of English.
Ph.D., University of North Carolina.
- John R. Lambert, Associate Professor of Social Studies.
Ph.D., Princeton University.
- John Harold Lampe, Professor of Electrical Engineering and Dean of the School of Engineering.
Dr. Eng., Johns Hopkins University.
- Forrest Wesley Lancaster, Professor of Physics.
Ph.D., Duke University.
- John Giacomo Lecce, Associate Professor of Animal Industry.
Ph.D., University of Pennsylvania.
- Thomas Benson Ledbetter, Assistant Professor of Mechanical Engineering.
M.S., N. C. State College.
- John Francis Lee, Broughton Professor of Mechanical Engineering and Head of Department.
M.S., Harvard University.
- Joshua A. Lee, Research Assistant Professor of Field Crops.
Ph.D., University of California.
- James Edward Legates, Reynolds Professor of Animal Industry.
Ph.D., Iowa State College.
- Jack Levine, Professor of Mathematics.
Ph.D., Princeton University.

- Clarence Earl Libby, Reuben B. Robertson Professor of Pulp and Paper Technology.
Ch.E., University of Maine.
- John S. Little, Visiting Lecturer in Industrial Engineering.
B.S., Massachusetts Institute of Technology.
- Robert W. Llewellyn, Associate Professor of Industrial Engineering.
M.S., Purdue University.
- Richard Henry Loeppert, Professor of Chemistry.
Ph.D., University of Minnesota.
- George Gilbert Long, Assistant Professor of Chemistry.
Ph.D., University of Florida.
- Roy Lee Lovvorn, Professor of Field Crops and Director of Research in the School of Agriculture.
Ph.D., University of Wisconsin.
- George Blanchard Lucas, Research Associate Professor of Plant Pathology.
Ph.D., Louisiana State University.
- Henry Laurence Lucas, Jr., Reynolds Professor of Experimental Statistics.
Ph.D., Cornell University.
- James Fulton Lutz, Professor of Soils.
Ph.D., University of Missouri.
- Joseph Thomas Lynn, Associate Professor of Physics.
M.S., Ohio State University.
- Glenn C. McCann, Assistant Professor of Rural Sociology.
Ph.D., Washington State College.
- Charles B. McCants, Associate Professor of Soils.
Ph.D., Iowa State College.
- Robert E. McCollum, Research Assistant Professor of Soils.
Ph.D., University of Illinois.
- Clarence Leslie McCombs, Associate Professor of Horticulture.
Ph.D., Ohio State University.
- Ralph J. McCracken, Associate Professor of Soils.
Ph.D., Iowa State College.
- Charles Russell McCullough, Professor of Civil Engineering.
M.S., Purdue University.
- Patrick Hill McDonald, Research Professor of Mechanical Engineering and Graduate Administrator.
Ph.D., Northwestern University.
- William McGehee, Visiting Professor of Psychology.
Ph.D., Peabody College.
- John Joseph McNeill, Assistant Professor of Animal Industry.
Ph.D., University of Maryland.
- Francis Edward McVay, Associate Professor of Experimental Statistics.
Ph.D., University of North Carolina.
- James G. Maddox, Professor of Agricultural Economics.
Ph.D., Harvard University.
- T. Ewald Maki, Carl Alwin Schenck Professor of Forest Management.
Ph.D., University of Minnesota.
- Carroll Lamb Mann, Jr., Professor of Civil Engineering.
C.E., Princeton University.
- Thurston Jefferson Mann, Professor of Field Crops.
Ph.D., Cornell University.
- David Hamilton Martin, Assistant Professor of Physics.
M.S., University of Wisconsin.
- David Dickenson Mason, Professor of Experimental Statistics.
Ph.D., N. C. State College.

- Gennard Matrone, Research Professor of Animal Industry.
Ph.D., N. C. State College.
- Dale Frederick Matzinger, Assistant Professor of Genetics and Experimental Statistics.
Ph.D., Iowa State College.
- Jack R. Mauney, Research Assistant Professor of Field Crops.
Ph.D., University of Wisconsin.
- Selz Cabot Mayo, Professor of Rural Sociology.
Ph.D., University of North Carolina.
- Jefferson Sullivan Meares, Professor of Physics.
M.S., N. C. State College.
- Adolph Mehlich, Research Associate Professor of Soils.
Ph.D., University of Wisconsin.
- Arthur Clayton Menius, Jr., Professor of Physics and and Head of Department.
Ph.D., University of North Carolina.
- Lawrence Eugene Mettler, Assistant Professor of Genetics.
Ph.D., University of Texas.
- Gordon Kennedy Middleton, Professor of Field Crops.
Ph.D., Cornell University.
- Conrad Henry Miller, Assistant Professor of Horticulture.
Ph.D., Michigan State University.
- Howard G. Miller, Professor of Psychology and Head of Department.
Ph.D., Pennsylvania State University.
- Philip Arthur Miller, Professor of Field Crops.
Ph.D., Iowa State.
- William Dykstra Miller, Associate Professor of Forestry.
Ph.D., Yale University.
- Walter Joseph Mistic, Associate Professor of Entomology.
Ph.D., A & M College of Texas.
- Adolphus Mitchell, Professor of Engineering Mechanics.
M.S., University of North Carolina.
- Theodore Bertis Mitchell, Professor of Entomology.
D.S., Harvard University.
- Richard D. Mochrie, Assistant Professor of Animal Industry.
Ph.D., N. C. State College.
- Robert Harry Moll, Assistant Professor of Genetics and Experimental Statistics.
Ph.D., N. C. State College.
- Robert James Monroe, Professor of Experimental Statistics.
Ph.D., N. C. State College.
- Elmer Leon Moore, Professor of Plant Pathology.
Ph.D., University of Wisconsin.
- Robert Parker Moore, Professor of Field Crops.
Ph.D., Ohio State University.
- Charles G. Morehead, Associate Professor of Occupational Information and Guidance.
Ed.D., University of Kansas.
- Donald Edwin Moreland, Assistant Professor of Field Crops.
Ph.D., N. C. State College.
- Carey Gardner Mumford, Professor of Mathematics.
Ph.D., Duke University.
- W. Ray Murley, Associate Professor of Animal Industry.
Ph.D., Iowa State College.

- Edward A. Murray, Professor of Textile Chemistry and Director of Instruction in the School of Textiles.
Ph.D., University of Texas.
- Raymond LeRoy Murray, Burlington Professor of Physics and Graduate Administrator.
Ph.D., University of Tennessee.
- Howard M. Nahikian, Professor of Mathematics.
Ph.D., University of North Carolina.
- Richard Robert Nelson, Associate Professor of Plant Pathology.
Ph.D., University of Minnesota.
- William A. Newell, Professor of Textiles and Director of the Textile Research Center.
B.S., N. C. State College.
- Slater Edmund Newman, Associate Professor of Plant Pathology.
Ph.D., Northwestern University.
- Lowell Wendell Nielsen, Professor of Plant Pathology.
Ph.D., Cornell University.
- Stuart Noblin, Professor of History and Political Science.
Ph.D., University of North Carolina.
- Charles Joseph Nusbaum, Reynolds Professor of Plant Pathology.
Ph.D., University of Wisconsin.
- Bernard Martin Olsen, Associate Professor of Economics.
Ph.D., University of Chicago.
- John Clark Osborne, Research Professor of Animal Industry and Head of Veterinary Section.
D.V.M., Michigan State College.
- Hubert Vern Park, Professor of Mathematics.
Ph.D., University of North Carolina.
- Thomas H. Park, Assistant Professor of Economics.
A.B., Vanderbilt University.
- John Mason Parker, III, Professor of Geology.
Ph.D., Cornell University.
- Thomas Oliver Perry, Associate Professor of Forestry.
Ph.D., Harvard University.
- Walter John Peterson, Reynolds Professor of Chemistry and Dean of the Graduate School.
Ph.D., University of Iowa.
- Wilbur Carroll Peterson, Associate Professor of Electrical Engineering.
Ph.D., Northwestern University.
- Lyle L. Phillips, Assistant Professor of Field Crops.
Ph.D., University of Minnesota.
- Walter Henry Pierce, Professor of Agricultural Economics.
Ph.D., University of Minnesota.
- Frederick Phillips Pike, Professor of Chemical Engineering.
Ph.D., University of Minnesota.
- Robert McLean Pinkerton, Professor of Aeronautical Engineering.
B. Sc., Bradley University.
- George Waverly Poland, Professor of Modern Languages and Head of Department.
Ph.D., University of North Carolina.
- Daniel Townsend Pope, Research Associate Professor of Horticulture.
Ph.D., Cornell University.
- Joseph Alexander Porter, Jr., Associate Professor of Textiles.
M.S., N. C. State College.

- Richard Joseph Preston, Professor of Forestry and Dean of the School of Forestry.
Ph.D., University of Michigan.
- Thomas Lavalley Quay, Professor of Zoology.
Ph.D., N. C. State College.
- Robert Lamar Rabb, Associate Professor of Entomology.
Ph.D., N. C. State College.
- Harold Arch Ramsey, Assistant Professor of Animal Industry.
Ph.D., N. C. State College.
- Horace D. Rawls, Associate Professor of Sociology and Anthropology.
M.S., N. C. State College.
- Preston Harding Reid, Assistant Professor of Soils.
Ph.D., N. C. State College.
- Willis Alton Reid, Professor of Chemistry.
Ph.D., University of Wisconsin.
- Ladislav Francis Reitzer, Assistant Professor of History and Political Science.
Ph.D., School of International Studies, Geneva, Switzerland; University of Chicago.
- Robert Barton Rice, Professor of Mechanical Engineering.
M.E., Tufts College.
- Frances M. Richardson, Research Associate Professor of Engineering Research.
M.S., University of Cincinnati.
- Jackson Ashcraft Rigney, Professor of Experimental Statistics and Head of Department.
M.S., Iowa State College.
- William Milner Roberts, Professor of Animal Industry and Head of Dairy Manufacturing Section.
Ph.D., University of Minnesota.
- Cowin Cook Robinson, Professor of Chemistry.
Ph.D., University of Wisconsin.
- Harold Frank Robinson, Professor of Genetics and Experimental Statistics and Head of Department of Genetics.
Ph.D., Nebraska University.
- Paul James Rust, Associate Professor of Psychology and English.
Ph.D., University of Washington.
- Henry Ames Rutherford, Professor of Textile Chemistry and Head of Department.
M.A., George Washington University.
- John A. Santolucito, Assistant Professor of Zoology.
Ph.D., University of California.
- Joseph Neal Sasser, Associate Professor of Plant Pathology.
Ph.D., University of Maryland.
- George Howard Satterfield, Professor of Chemistry.
M.A., Duke University.
- Clarence Cayce Scarborough, Professor of Agricultural Education and Head of Department.
Ed.D., University of Illinois.
- Edward Martin Schoenborn, Jr., Professor of Chemical Engineering and Head of Department.
Ph.D., Ohio State University.
- Robert Johnson Schramm, Assistant Professor of Horticulture.
Ph.D., Duke University.
- Herbert Temple Scofield, Professor of Botany and Head of Department.
Ph.D., Cornell University.

- John Frank Seely, Associate Professor of Chemical Engineering.
M.S., North Carolina State College.
- Heinz Seltmann, Assistant Professor of Botany.
Ph.D., University of Chicago.
- Luther Shaw, Associate Professor of Field Crops.
Ph.D., University of Wisconsin.
- Ching S. Shen, Assistant Professor of Economics.
Ph.D., University of North Carolina.
- Francis Webber Sherwood, Professor Emeritus of Animal Industry.
Ph.D., Cornell University.
- Robert T. Sherwood, Research Assistant Professor of Plant Pathology.
Ph.D., University of Wisconsin.
- William Edward Shinn, Chester H. Roth, Professor of Knitting; Head,
Knitting Department, School of Textiles.
M. S., N. C. State College.
- John William Shirley, Professor of English and Dean of the Faculty.
Ph.D., University of Iowa.
- Charles Smallwood, Jr., Professor of Civil Engineering and Graduate Ad-
ministrator.
M.S., Harvard University.
- William Wesley Garry Smart, Jr., Research Assistant Professor of Animal
Industry and Experimental Statistics.
Ph.D., North Carolina State College.
- Michael V. Smirnoff, Associate Professor of Civil Engineering.
Ph.D., University of California.
- Benjamin Warfield Smith, Professor of Genetics.
Ph.D., University of Wisconsin.
- Clyde Fuhrman Smith, Professor of Entomology and Head of Department.
Ph.D., Ohio State University.
- Frank Houston Smith, Research Associate Professor of Animal Industry.
M.S., N. C. State College.
- Rufus Hummer Snyder, Professor of Physics.
Ph.D., Ohio State University.
- William Thomas Snyder, Assistant Professor of Mechanical Engineering.
Ph.D., Northwestern University.
- Marvin Luther Speck, Reynolds Professor of Animal Industry.
Ph.D., Cornell University.
- William Eldon Splinter, Associate Professor of Agricultural Engineering.
Ph.D., Michigan State University.
- Hans Heinrich Anton Stadelmaier, Research Professor of Mineral Industries.
M.S., Technische Hochschule, Stuttgart, Germany.
- Alfred J. Stamm, Research Associate Professor of Wood Technology.
Ph.D., University of Wisconsin.
- Charles J. Standish, Visiting Associate Professor of Mathematics.
Ph.D., Cornell University.
- William A. Stephen, Extension Beekeeper in Entomology.
M.A., University of Toronto, Canada.
- Robert Lawrence Stephens, Research Associate Professor of Chemistry.
Ph.D., University of Florida.
- Stanley G. Stephens, Reynolds Professor of Genetics.
Ph.D., Edinburgh University, Scotland.
- William Damon Stevenson, Jr., Professor of Electrical Engineering and
Graduate Administrator.
M. S., University of Michigan.

- Hamilton Arlo Stewart, Professor of Animal Industry and Assistant Director of Research in the School of Agriculture.
Ph.D., University of Minnesota.
- Robert Franklin Stoops, Research Professor of Ceramic Engineering.
Ph.D., Ohio State University.
- Raimond Aldrich Struble, Associate Professor of Mathematics.
Ph.D., University of Notre Dame.
- Paul Porter Sutton, Professor of Chemistry.
Ph.D., Johns Hopkins University.
- Ernst W. Swanson, Professor of Economics and Head of Department.
Ph.D., University of Chicago.
- Walter Earl Thomas, Professor of Animal Industry.
Ph.D., Cornell University.
- Donald Loraine Thompson, Associate Professor of Field Crops.
Ph.D., Iowa State College.
- George Stanford Tolley, Professor of Agricultural Economics.
Ph.D., University of Chicago.
- John W. Tomlin, Assistant Professor of Sociology and Anthropology.
Ph.D., University of Maryland.
- Huseyin C. Topakoglu, Instructor in Mechanical Engineering.
D.Sc., Technical University of Istanbul.
- William Douglas Toussaint, Associate Professor of Agricultural Economics.
Ph.D., Iowa State College.
- Samuel B. Tove, Research Associate Professor of Animal Industry and Chemistry.
Ph.D., University of Wisconsin.
- James Richard Troyer, Assistant Professor of Botany.
Ph.D., Columbia University.
- Lester Curtis Ulberg, Associate Professor of Animal Industry.
Ph.D., University of Wisconsin.
- Newton Underwood, Professor of Physics.
Ph.D., Brown University.
- Robert Phillip Upchurch, Research Assistant Professor of Field Crops.
Ph.D., University of California.
- Mehmet Ensar Uyanik, Professor of Civil Engineering.
Ph.D., University of Illinois.
- Jan van Schilfgaarde, Research Associate Professor of Agricultural Engineering.
Ph.D., Iowa State College.
- Richard J. Volk, Associate Professor of Soils.
Ph.D., N. C. State College.
- David Rudger Walker, Associate Professor of Horticulture.
Ph.D., Cornell University.
- Arthur W. Waltner, Professor of Physics.
Ph.D., University of North Carolina.
- Frederick Gail Warren, Associate Professor of Animal Industry.
Ph.D., Pennsylvania State College.
- David S. Weaver, Professor of Agricultural Engineering.
M.S., N. C. State College.
- Sterling B. Weed, Assistant Professor of Soils.
Ph.D., N. C. State College.
- Bertram W. Wells, Professor Emeritus of Botany.
Ph.D., University of Chicago.
- Joseph Arthur Weybrew, Reynolds Professor of Agronomy and Chemistry.
Ph.D., University of Wisconsin.

- Raymond Cyrus White, Associate Professor of Chemistry.
Ph.D., West Virginia University.
- John Kerr Whitfield, Associate Professor of Mechanical Engineering.
M.S., N. C. State College.
- Larry Alston Whitford, Professor of Botany.
Ph.D., Ohio State University.
- Benjamin Lincoln Whittier, Edgar and Emily Hesslein Professor of Fabric Development and Construction, School of Textiles.
B.S., Williams College.
- Rudolph Willard, Visiting Lecturer in Industrial Engineering.
Ph.B., Yale University.
- Carlos Frost Williams, Professor of Horticulture.
M.S., N. C. State College.
- James Claude Williamson, Associate Professor of Agricultural Economics.
M.S., N. C. State College.
- Nash Nicks Winstead, Associate Professor of Plant Pathology.
Ph.D., University of Wisconsin.
- Sanford Richard Winston, Professor of Sociology and Head of Department.
Ph.D., University of Minnesota.
- Lowell Sheridan Winton, Professor of Mathematics.
Ph.D., Duke University.
- George Herman Wise, Reynolds Professor of Animal Industry; Head, Animal Nutrition Section.
Ph.D., University of Minnesota.
- Milton B. Wise, Assistant Professor of Animal Industry.
Ph.D., Cornell University.
- Willie Garland Woltz, Professor of Soils.
Ph.D., Cornell University.
- James Woodburn, Professor of Mechanical Engineering.
Dr. Engr., Johns Hopkins University.
- William Walton Woodhouse, Professor of Soils.
Ph. D., Cornell University.
- David Allan Young, Associate Professor of Entomology.
Ph.D., University of Kansas.
- James N. Young, Assistant Professor of Rural Sociology.
Ph.D., University of Kentucky.
- Talmage Brian Young, Associate Professor of Industrial Arts Education.
Ph.D., University of Florida.
- Bruce J. Zobel, Professor of Forestry.
Ph.D., University of California.

THE GRADUATE SCHOOL OF THE UNIVERSITY OF NORTH CAROLINA

STATE COLLEGE DIVISION

William M. Whyburn, Vice-President, Graduate Studies and Research
Walter John Peterson, Dean, Raleigh

ORGANIZATION

The Graduate School of the Consolidated University of North Carolina is composed of three divisions, one at each of the three units of the University System. Each branch of the Consolidated Graduate School is administered by a Graduate Dean who works in close association with the Vice-President in charge of Graduate Studies and Research. The Graduate Council is composed of representatives of the Administrative Boards of each of the three units of the Consolidated University. At State College the Graduate Dean is assisted in all matters of policy by an Administrative Board of seven members, five of whom are elected by the faculties of the degree-granting schools, the remaining two being appointed by the Chancellor after consultation with the Dean.

Graduate instruction at State College is organized to provide opportunity and facilities for advanced study and research in the fields of Agriculture, Engineering, Forestry, Technological Education, and Textiles. The purpose of these graduate programs is to develop in advanced students a more adequate comprehension of the scope of knowledge in these special fields of learning and an understanding of the requirements and responsibilities essential for independent research investigations. In all of the graduate programs emphasis is placed upon a high level of scholarship rather than upon the satisfaction of specific course or credit requirements.

Facilities.—The full resources of the Consolidated University of North Carolina are made available to all graduate students enrolled at any one of the three branches of the Graduate School. Exceptional facilities for graduate study are provided at State College. New buildings furnish modern well equipped laboratories for graduate study in specialized areas of Agriculture, Engineering, Forestry, and Textiles. One of the new buildings houses a nuclear reactor. Research facilities are available in the new reactor building for graduate students in physics, engineering and the biological sciences.

The North Carolina Agricultural Experiment Station and the Department of Engineering Research are integral parts of the College. The Staff, research facilities, equipment, and field studies of these organizations contribute in a very important way to the graduate programs of the College. The presence of the Institute of Statistics on the State College Campus makes available to graduate students unusual opportunities in this important phase of research study.

The state of North Carolina, extending from the Atlantic Ocean westward about 500 miles to the high Appalachian Mountains, possesses an exceptional range of climatic and topographic environments. The coastal plain, the piedmont, and the mountains provide a rich pattern of agricultural and

industrial activities which offer unusual opportunities for research study and employment.

State College is located in Raleigh, a city of 89,000, situated on the boundary separating the broad coastal plains on the east from the rolling terrain of the piedmont on the west, about midway between the northern and southern boundaries of the state. Raleigh is 29 miles from Chapel Hill, the location of the University of North Carolina, and 26 miles from Durham, the home of Duke University. The libraries and other facilities of the three institutions make this area one of the important centers of research opportunity in the South.

The College Library

The N. C. State College Library has excellent holdings in materials essential for research study in the graduate curricula offered by the college.

As of July 1, 1959 the College Library held more than 194,000 volumes of books and bound journals, including more than 17,000 bound documents. The books and journals have been selected to reflect strongly the scientific and technological interests of the College, and the documents represent a most important increment of the whole collection. They include, in addition to the publications of the Federal government, all publications of the various Agricultural Experiment Stations, most of the publications of the Engineering Experiment and Engineering Research Stations, and publications of the various research stations from all over the world.

The depository status of the College Library may be described as follows:

1. The Library is a complete depository for all unclassified publications of the Federal government that are available for distribution. This includes, of course, publications of the U.S.D.A., Geological Survey, National Bureau of Standards, Department of Interior, etc. Since 1923, the year the library was designated as a depository, our document holdings in the fields of our special interest are almost 100% complete.
2. The Library is a "selective" depository for the publications of the Carnegie Institution of Washington. The Library has excellent files of these valuable monographs.
3. The Library is a depository for all unclassified and declassified publications of the Atomic Energy Commission.
4. The Library receives on exchange the publications of many foreign countries—especially publications dealing with the agriculture sciences and with engineering.

The resources of the College library together with the generous assistance given to us by our sister institution, the University Library at Chapel Hill, and inter-library loan service available from other scientific libraries make the D. H. Hill Library of the North Carolina State College a highly satisfactory adjunct of the graduate program of the College.

A reciprocal arrangement has been made with the library at the University of North Carolina and the Duke University Library whereby their facilities are available to our faculty and graduate students who may wish to deal with these libraries directly.

Identification certificates may be secured at the office of the director of the State College Library.

Research Program at the Oak Ridge Institute of Nuclear Studies

North Carolina State College as a unit of the Consolidated University of North Carolina is one of the sponsoring institutions of the Oak Ridge Institute of Nuclear Studies located at Oak Ridge, Tennessee. Through this cooperative association with the Institute our graduate research program has at its disposal the facilities and research staff of Oak Ridge National Laboratory. An extensive research program is underway there on the physical and biological effects of radiations, uses of radioisotopes and many other nuclear physics and chemical processes. When master's and doctoral candidates have completed their resident work, it may be possible, by special arrangement, for them to go to Oak Ridge to do their research problems and prepare their theses. In addition, it is possible for the staff members of this university to go to Oak Ridge for varying periods, usually not less than three months for advanced study in their particular fields.

Institute of Statistics

The development of the Institute of Statistics has made an important contribution to the graduate program at State College. The Institute is organized as a part of the Consolidated University of North Carolina with a section at State College and a section at the University at Chapel Hill.

By utilizing the combined strengths of the two groups in most of its work, the Institute draws upon the excellent background of theory and the experience of application found in few institutions in the world. The instructional program is backed by an active responsibility in consulting with institutional and contract research projects and by an increasing volume of research in statistics and methodology.

Computing Facilities

There are a number of high speed computing facilities available to graduate instruction and research.

An IBM 650 electronic digital computer is located in the Institute of Statistics, Patterson Hall, and is available for graduate student research. It is also used in connection with courses and short courses in computer theory and operation. It is supplemented by a full complement of other IBM machines.

A GEDA (Goodyear Electronic Differential Analyzer) is in use in the Mathematics Department's research and graduate instruction program, particularly in problems involving large scale linear and non-linear differential equations.

Several Donner analog computers are in use on the campus in classroom instruction and research projects.

The Textile School has an IBM 610 digital computer used in their research and graduate student instruction.

A UNIVAC (Remington Rand 1105) is in operation at the University at Chapel Hill and is also available for faculty and graduate student research.

THE GRADUATE DEGREES

The Graduate School of State College offers work leading to the Master of Science degree in the specialized branches of Agriculture, Education, Engineering, Forestry and Textiles; the Professional Master's degree in Agriculture, Agricultural Education and Forestry; and the Doctor of Philosophy degree in certain fields of Agriculture, Engineering, and Forestry.

A graduate student is expected to familiarize himself with the requirements for the degree for which he is a candidate and is held responsible for the fulfillment of these requirements. This applies to the last dates on which theses may be accepted, the dates for examinations, the proper form of theses, and all other matters regarding requirements for degrees.

ADMISSION

Admission may be to full graduate standing, provisional or in an unclassified status. All applications for admission to the Graduate School must be accompanied by official transcripts from all colleges previously attended.

Full Graduate Standing. For admission in this category a student must have a Bachelor's degree from a recognized college or university regarded as standard by a regional or general accrediting agency and at least a B grade average in the undergraduate major.

Provisional admission may be granted to applicants who lack undergraduate work, considered essential for graduate study in the major field. Course work, without graduate credit, will be required to make up such deficiencies before admission to full graduate status can be granted.

Graduates from non-accredited institutions may be granted provisional admission when their academic records warrant. Additional course work will be required of such students when deficiencies in their previous training are apparent.

Graduates from accredited institutions whose scholastic records are below the standards for admission to full graduate standing may be admitted provisionally when unavoidable extenuating circumstances affected their undergraduate averages or when progressive improvement in their undergraduate programs warrant. All such students are required to take the Graduate Record Examinations and to submit scores to the Graduate Office in support of their application. The National Teacher's Examination may be substituted for the Graduate Record Examination if recommended by the department head. Information as to the dates on which the Graduate Record and the National Teacher's Examinations are given may be obtained at the Graduate Office.

Graduate students admitted on a provisional status may attain full graduate standing when the deficiencies responsible for their provisional status have been corrected. They also must have maintained a satisfactory academic record in all course work taken as a part of their graduate program. Change from provisional to full graduate standing is effected only on written recommendation from the department in which the student is seeking his degree.

Unclassified graduate students are not candidates for graduate degrees.

They may take courses for graduate credit, but may not apply more than 10 credits earned while in the unclassified status to any program leading to an advanced degree at this institution. Unclassified graduate students are expected to meet the same admission requirements that apply to graduate students in full standing.

Applications for admission to the Graduate School should be on file in the Graduate Office at least thirty days in advance of the registration date for the term in which the student wishes to enroll in the Graduate School.

Students who apply for admission to the Graduate School without having allowed sufficient time for the study of completed transcripts, or prior to the receipt of their scores on the Graduate Record Examinations, may be admitted as unclassified students. When evaluation of completed transcripts or satisfactory performance on the Graduate Record Examinations warrant, such students may be transferred during the semester to full or provisional status. Unless transcripts or Graduate Record Examination scores are received within a reasonable time after admission or when evaluation of transcripts or scores on the Graduate Record Examinations indicate unsatisfactory qualifications for graduate study, no graduate credit may be received for course work.

The Office of Registration must have written authorization from the Dean of the Graduate School before any graduate student will be given a permit to register. This permit will be sent to the Office of Registration by the Graduate Dean at the time the student is notified of his acceptance.

A full-time graduate load is considered to be 15 credits per semester. This course load restriction is made so that graduate students may have time for reading and contemplation well beyond the limits set for satisfactory undergraduate work. In exceptional cases one or two additional credit hours may be added to the roster if necessary in order to get prerequisite work which is not taught in subsequent terms, provided the corresponding adjustment in course load is made in the other terms. Rosters with additional credit hours beyond 15 should be accompanied by a special note from the head of the major department indicating the reasons for the additional work.

Full-time employees of the College may register for one course in each semester. Registration for two courses will be permitted (a) when a reduction in the service obligation of the employee releases time that may be devoted to graduate study or (b) when the total credits do not exceed four. Staff members whose service obligations are reduced in any given semester will be permitted a proportionate increase in graduate course work.

Employees of the College having academic rank higher than that of instructor may register for graduate work for credit to be transferred to other institutions. They may not undertake programs for graduate degrees in the Consolidated University of North Carolina.

Graduate assistants on half-time appointments are permitted a maximum course load of 9 credits per semester unless corresponding adjustments are made in their service obligations during the same semester. If the appointment is for the academic year of 9 months, half-time assistants are restricted to a maximum of 18 credit hours of work during the 9 months of their appointment. Half-time graduate assistants whose appointments are

for 12 months may not exceed a total of 24 credits during the 12 month period of their appointment.

A member of the senior class of State College may, upon approval of the Dean of the Graduate School, register for courses in the 500 group for graduate credit to fill a roster of studies not to exceed 15 credits in any semester. Not more than 6 hours of graduate credit may be acquired by an undergraduate student. Courses listed with numbers in the 600 series are not open to undergraduates.

All regularly enrolled graduate students must take a physical examination. Preferably this should be given by the family physician on forms provided by the College. When this is not done the examination may be taken at the College during registration. A fee of \$5.00 will be charged for the examination when it is given by the College physician.

Admission to Candidacy for Graduate Degrees

Admission to the Graduate School does not constitute admission to candidacy for a graduate degree. Application for admission to candidacy for graduate degrees must be submitted to the Administrative Board of the Graduate School. Applications of students preparing for the Master's degree may not be filed before the satisfactory completion of one full semester of graduate study and must be presented before the end of the first week of the last semester in residence. Approval of the application will be determined by the quality of the scholastic record and on the certification by the major department that the student is qualified to continue advanced work. Admission to candidacy for the doctorate is granted upon satisfactory completion of the qualifying or preliminary examinations.

MASTER OF SCIENCE DEGREE

The Master of Science degree is awarded at State College after completion of a course of study in specialized fields in Agriculture, Education, Engineering, Forestry or Textiles; demonstration of ability to read a modern foreign language; completion of a satisfactory thesis and of comprehensive examinations in the chosen field of study.

In addition to complying with these requirements, the candidate for the Master of Science degree is expected to achieve high levels of scholarship. Graduate study is distinguished from undergraduate work by its emphasis upon independent research. The graduate student is more interested in the significance of facts than in the accumulation of data. He is concerned with the materials of learning and the organization and interpretation of these materials.

A graduate student's program of study is planned so as to provide a comprehensive view of some major field of interest and to furnish the training essential for successful research in this field and related areas of knowledge. As great a latitude is permitted in the selection of courses as is compatible with a well-defined major interest. The program of course work is selected with the object of making possible a reasonable mastery of the subject matter in a specialized field. Training in research is provided to give the student familiarity with the methods, ideals, and goals

of independent investigation. Since there are many possible combinations of courses, the administration of graduate programs calls for personal supervision of each student's plan of work by a special advisory committee of the graduate faculty. (See page 30.) The program of course work to be followed by the student as a part of the requirements for the Master's degree and the thesis problem selected must be approved by the student's advisory committee and the Dean of the Graduate School.

Credits.—1. For the master of Science degree a minimum of thirty semester credits is required.

2. Not more than six of the academic credits required for a graduate degree will be accepted from other institutions.

3. No graduate credit will be awarded for excess undergraduate credit from any other institution.

4. All work credited toward a master's degree must be completed within six calendar years.

5. No graduate credit is allowed for courses taken by correspondence. A maximum of 6 semester credits may be obtained in extension study in the field of Education provided the extension courses are taught by a member of the Graduate Faculty and provided the courses are given graduate ranking by the Graduate School. Courses taken by extension are accepted for graduate credit only when the student has been admitted to the graduate school and when notice of registration is filed with the Graduate Office. Courses taken in extension study do not reduce the residence requirements unless they are a part of an approved program of work undertaken at an off-campus center approved by the Graduate School. Credit for extension courses reduces the amount of credit that may be transferred from other institutions by the amount of graduate credit granted.

Residence.—Students engaged in a course of study leading to the Master of Science degree are required to be in residence at the College, pursuing graduate work, one full academic year unless enrolled in an approved off-campus program of graduate study. Resident students are not permitted to complete the requirements for the Master of Science degree in a shorter period of time. Residence credit may not be transferred from another institution.

Residence credit is based on the number of credits carried in a given term. During a regular semester, residence credit is calculated in the following manner:

Semester Credits	Residence Credit
3 - 5	$\frac{1}{4}$ semester
6 - 8	$\frac{1}{2}$ semester
9 - 11	$\frac{3}{4}$ semester
12 - 15	1 semester

Six summer schools of six weeks in residence at the College are sufficient to fulfill the residence requirement. In a six weeks' summer session residence credit earned is determined by the following schedule:

Semester Credits	Residence Credit
6	$\frac{1}{3}$ semester
less than 6	$\frac{1}{4}$ semester

The thirty semester credit hour requirement for the Master's degree represents the minimum quantity of work acceptable. The credit hours

required of graduate students usually exceed the minimum requirements. Inadequate preparation and thesis research frequently make additional work necessary.

Courses of Study.—The program of the student shall contain at least eight semester credits in courses of the 600 group, no more than six of which may be allowed for research study. A maximum of two hours of seminar is permitted. Graduate students may use not more than six semester hours of course work of the 400 level for credit on programs leading to the Master's degree. To be acceptable for graduate credit, courses bearing a 400 number must fall in other than the student's major field of interest.

During the first term in residence an advisory committee of at least three faculty members, one representing the field of the minor, will be appointed by the Dean, after consultation with the head of the major department, for each student engaged in a program of work leading to the Master's degree. The advisory committee will meet with the student and prepare a program of course work to meet the requirements of the student's graduate objectives. Four copies of the program, prepared on forms provided for this purpose, must be approved by each member of the committee, by the head of the major department and the Dean of the Graduate School. After approval in the Graduate Office, three copies will be returned to the department head, one for his files, one for the chairman of the advisory committee and one for the student.

The courses taken by a graduate student shall constitute a well-rounded but unified plan of study. This is interpreted to mean that the program of research and course work shall be divided between a major and a minor field. While there are no inflexible rules which govern the number of credit hours that must constitute the major and minor, in general, it is expected that approximately two-thirds of the course work will fall in the major and one-third in the minor. The detailed course requirements for each graduate student program are left to the judgment of the advisory committee.

Class Work.—A graduate student is expected to show greater initiative in exploring the possibilities of the subject matter presented in the courses he takes than is the undergraduate. He is also expected to recognize the significance of facts and to assume a responsibility for relating data to theoretical concepts. In preparation, attendance, and in all the routine of class work the graduate student is subject to the regulations observed in other divisions of the college.

Grades.—A minimum grade of C must be made on *all* formal course work to obtain graduate credit. An average of B must be obtained on all course work taken as a part of the student's graduate program. Failure to maintain a B average in any term will place the student upon probation. Any student whose academic record fails to meet the B average requirement for two consecutive terms will not be permitted to continue a graduate program without the written approval of the Dean.

Grades in research, seminar and special problem courses are given in terms of S (satisfactory) or U (unsatisfactory) in place of the symbols used for formal course work.

The grade *Incomplete* may be used in research or laboratory courses when circumstances beyond the control of the student have prevented completion of the work by the end of the academic term. An incomplete grade may be given only after approval by the Dean and must be converted to one of the usual symbols before the end of the next academic semester in which the student is in residence.

Language Requirements.—A reading knowledge of at least one modern foreign language (Germanic, Romance or Slavic) is required of candidates for the Master of Science degree.

The language requirement must be satisfied before a student can be admitted to candidacy.

Proficiency in languages is determined by the Department of Modern Languages on the basis of a traditional reading knowledge examination. Students whose language preparation is adequate may take their language examination by appointment at any time during the academic year. The Department of Modern Languages offers course work to assist graduate students who desire to improve their comprehension of foreign languages but no course work in language is required of graduate students. Graduate students who expect to complete the requirements for the Master of Science degree should confer with the Head of the Department of Modern Languages soon after registration to formulate plans for meeting the language requirements of this degree.

Students whose native language is other than English may meet the foreign language requirement for the Master of Science degree by demonstrating a satisfactory mastery of English. Examinations in English are conducted by the English Department.

Thesis.—A candidate for the Master of Science degree must prepare a thesis representing an original investigation. The subject of the thesis must be approved by the Head of the Department in which the major work is done and by the student's advisory committee. Three copies of the thesis in final form and five copies of the abstract must be filed in the Graduate Office at least one month before the degree is awarded. The abstract will be published by the College. Detailed instructions as to form and organization of the thesis may be obtained at the Graduate Office.

Examinations.—All candidates for the Master of Science degree must pass, with a grade of A, B, or C, all formal course work specified as a part of the requirements for the degree. Graduate credit for research, seminar and special problems courses is granted when a grade of S is recorded in the Registration Office. In addition, the candidate must pass a comprehensive oral examination that is held to satisfy the examining committee that the candidate possesses a reasonable mastery of knowledge in the major and minor fields and that this knowledge can be used with promptness and accuracy. This examination may not be held until all other requirements except completing the course work of the last semester are satisfied but must be taken not later than two weeks before the end of the semester in which the degree is to be awarded. Application for the comprehensive oral examination must be filed with the Graduate Dean by the chairman of the advisory committee at least one week prior to the date on which the examination is to be held.

The oral examination will be conducted by an examining committee

appointed by the Graduate Dean. The chairman of the examining committee will be the chairman of the student's advisory committee. At least two additional members will be appointed to represent the major and minor fields. The comprehensive oral examination is open to all faculty members who care to attend but the decision as to the candidate's fitness rests solely with the examining committee.

At the discretion of the examining committee, written examinations covering the subject matter in the major and minor fields also may be required of the candidate. Written examinations, when required, may not be held earlier than the end of the first month of the last semester in residence, and not later than one week before the comprehensive oral examination.

The final examination for candidates for the Master's degree may not be held until the thesis, in complete and final form, bearing the signature of the chairman of the student's advisory committee, has been submitted to the Graduate Office.

MASTER'S DEGREE IN A PROFESSIONAL FIELD

This degree is offered for students who are interested in the more advanced applications of fundamental principles to specialized fields rather than in the acquisition of the broader background in the advanced scientific studies which would fit them for careers in research. Students working for this degree ordinarily will terminate their graduate work at this point.

Examples of the types of degrees that may be awarded upon the completion of the course of study in a professional field are:

Master of Agricultural Education

Master of Forestry

Master of Agricultural Engineering

The degree is not offered in the Schools of Engineering and Textiles.

The chief characteristic of these degrees is that the changes made in requirements permit, in greater measure, the satisfaction of what are represented as professional needs than do the requirements for the conventional Master of Science degree. The most important modification in the requirements is the greater emphasis upon the applied rather than the basic sciences.

Language Requirements.—The candidate for a Master's degree in a professional field is exempt from the requirements of a reading knowledge of a modern foreign language.

Thesis Requirements.—In the School of Education the thesis requirement for the Master's degree in each of the specialized fields may be waived by the department in which the degree is sought. When the thesis requirement is waived the student must complete the course Introduction to Educational Research, or departmental course in research and a problem report. A thesis is required for the professional degree in Agriculture and Forestry.

Other Requirements.—The other requirements for the Master's degree in a professional field are the same as for the Master of Science degree.

THE MASTER OF AGRICULTURE DEGREE

This plan is offered for the students who are interested in advanced training in the broad field of agriculture but whose responsibility is not

in research. The requirements for the degree are designed to provide an opportunity for professional training without narrow specialization to those who plan to devote their lives to some phase of practical agriculture. Among the individuals interested would be agricultural extension workers and foreign students who are in action or educational programs. The proposed plan differs from the plan for the Master of Science degree in the following principal respects:

1. A total of 36 semester credits is required.
2. A minimum of four semester credits in special problems is required. Not more than six semester credits in special problems will be allowed. This work replaces the research thesis requirement of the Master of Science degree.
3. There are no specific requirements as to courses in the 600 group.
4. A reading knowledge of a modern foreign language is not required.

In all other respects the requirements for the Master of Agriculture degree are the same as those for the Master of Science degree.

SUMMARY OF PROCEDURES FOR THE MASTER'S DEGREE

1. Letter of inquiry from prospective student to Graduate Office or Department Head.
2. Mailing of proper forms to student by Graduate Office or Department Head.
3. Receipt of application form and transcript by Graduate Office.
4. Application with transcript sent to Department Head for study.
5. Department Head recommends acceptance of prospective student stating curriculum in which he will work and the degree sought.
6. Assuming the prospective student meets the minimum scholastic standards, notice of acceptance is mailed to him by the Graduate Office. When the student's academic record fails to meet the minimum scholastic standards of the Graduate School, provisional admission may be granted upon submission by the student of evidence of a satisfactory performance on the Graduate Record or National Teacher's Examinations. The National Teacher's Examination is accepted only when approved by the Department Head and the Graduate Dean.
7. Permit to register is sent by the Graduate Office to the Registrar.
8. Student arrives, reports to the Department Head, is assigned an adviser, and makes out a roster of courses in consultation with departmental adviser.
9. Advisory committee of 3 or more faculty members, one of whom represents the minor field, appointed before the end of the first semester of graduate study by the Graduate Office after consultation with the Department Head.
10. Plan of work prepared by the advisory committee in consultation with the student and submitted in quadruplicate to the Graduate Office by the end of the first semester in residence.
11. Plan of work approved by the Graduate Dean and three copies returned to the Department Head. One copy is kept in department files, one goes to the advisor, and one is given to the student.
12. A thesis subject is selected and an outline of the proposed research submitted to the Department Head and to the student's advisory committee. Students preparing themselves for the professional degree in specialized fields of Education should consult the chairman of their committees with reference to their problem report.
13. Student passes language examination. Students preparing themselves for the master's degree in a professional field are not required to pass a language examination. The language requirement must be satisfied before admission to candidacy can be granted.
14. Student applies for admission to candidacy for the Master's degree. Application must be filed before the end of the first week of the last semester in residence and may not be filed before the language requirement is satisfied.
15. Application is reviewed by the head of the major department and by the Administrative Board and if approved the student becomes a candidate for the degree.
16. A copy of a preliminary draft of the thesis is submitted to the chairman of the student's committee for criticism. No thesis is required

- of candidate for the master's degree in specialized fields of Education.
17. Corrected draft of the thesis submitted to members of the student's advisory committee for additional suggestions and criticisms.
 18. Three copies of the thesis in final form approved by each member of the students advisory committee and signed by the advisor are submitted to the Graduate Office *at least one month prior to awarding of the degree.*
 19. Permission for student to take final examination requested of Graduate Office by chairman of student's advisory committee at least one week before the examination is to be held. Permission will not be granted until thesis in final and complete form has been received in the Graduate Office.
 20. Permission granted by Graduate Dean—date is set and examining committee appointed.
 21. Report of the examination sent to the Graduate Office at least two weeks prior to the date the degree is to be awarded.
 22. Graduate Office certifies to the Registration Office and to the General Faculty that all requirements for the degree have been met and recommends the awarding of the degree.
 23. Student must be registered in term in which degree is to be awarded.

THE DEGREE OF DOCTOR OF PHILOSOPHY

The degree of Doctor of Philosophy is offered in the following departments:

Agricultural Economics
Agricultural Engineering
Animal Industry
Botany (in the fields of physiology and ecology)
Ceramic Engineering
Chemical Engineering
Civil Engineering
Electrical Engineering
Entomology
Experimental Statistics
Field Crops
Forestry
Genetics
Physics (in the fields of engineering physics and
nuclear engineering)
Plant Pathology
Rural Sociology
Soils
Zoology (in the fields of ecology and wildlife biology).

REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

The Doctor's degree symbolizes the fact that the recipient is capable of undertaking original research and scholarly work at the highest levels without supervision. Therefore, the degree of Doctor of Philosophy is not

granted on a basis of the successful completion of a given amount of course work, but rather upon the demonstration by the candidate of a comprehensive knowledge and high attainments in scholarship and research in a specialized field of study. These attainments are determined by the quality of the dissertation which the candidate prepares to report the results of original investigations and by passing successfully a series of rigorous and comprehensive examinations on the special and related fields of study.

Residence.—A minimum of six full semesters of work beyond the Bachelor's degree is required for the Doctor of Philosophy Degree. Ordinarily, students who have the Master's degree will require two additional years of full time study to meet the requirements of the Doctor of Philosophy degree. At least one of these years must be spent in continuous residence at the Consolidated University of North Carolina.

The amount of credit granted for work accomplished at other institutions will be determined by the Dean after consultation with the student's advisory committee at the time the plan of graduate work is filed.

All work credited toward a Doctor of Philosophy degree must be completed within ten calendar years.

Course of Study.—At the time of admission the student should, with the advice of the chairman of the department, elect a major field. During the first semester in residence an advisory committee of at least five members will be appointed by the Graduate Dean, after consultation with the Department Head, to prepare with the student a plan of graduate work. Four copies of the program thus outlined, signed by all members of the advisory committee and the department head or graduate administrator are referred to the Graduate Dean for approval. When approved three copies are returned to the Department Head, one being retained in the department files, a second copy is given to the chairman of the advisory committee, and the third copy is given to the student. The subject of the dissertation must appear on the plan of work, and any subsequent changes in the subject of the thesis or in the plan of graduate work must be reported to the Graduate Office for approval.

There are no definite requirements in credit hours for the Doctor's degree. Emphasis is placed upon a comprehensive knowledge of a well defined and recognized field and related subjects. There shall be a major and one or two minor areas of specialization. The minor field ordinarily will consist of at least twenty semester credit hours. These may fall in an allied department or in the major department. A minor in the department of the major is permitted only when the department offers recognized divisions of study other than that designated as the major field.

Languages.—A reading knowledge of scientific literature in two modern foreign languages is required for the Doctor of Philosophy degree.

These two languages may be a combination of Romance and Slavic, Romance and Germanic, or Slavic and Germanic languages.

The language requirements must be satisfied before the qualifying examinations can be taken.

Proficiency in languages is determined by the Department of Modern Languages on the basis of a traditional reading knowledge examination. Students whose language preparation is adequate may take their language

examination by appointment at any time during the academic year. The Department of Modern Languages offers course work to assist graduate students who desire to improve their comprehension of foreign languages but no course work in language is required of graduate students. Graduate students who expect to complete the requirements for the Ph.D. degree should confer with the Head of the Department of Modern Languages soon after registration to formulate plans for meeting the language requirement of this degree.

Students whose native tongue is some language other than English may use English as one of the languages required for the Doctor of Philosophy degree. When English is submitted in partial fulfillment of the language requirements, the native language may not be used to satisfy the language requirements. Examinations in English will be given by the English Department, and a statement certifying the candidate's proficiency in English must be filed in the Graduate Office before the qualifying examination may be taken.

The Dissertation.—The doctoral dissertation presents the results of the candidate's original investigations in the field of his major interests. It must represent a contribution to knowledge adequately supported by data and written in a manner consistent with high standards of excellence in scholarship. Detailed instructions relating to the thesis may be obtained in the Graduate Office.

Publication of the results obtained in the thesis investigation is expected. Each copy of the thesis must be accompanied by an abstract of approximately 500 words. The abstract will be published by the College.

The dissertation will be examined by all members of the examining committee and must receive their approval to be acceptable to the Graduate Office.

Three copies of the dissertation in final form and bearing the signature of the chairman of the student's advisory committee must be presented to the Graduate Office not later than six weeks before the date on which the degree is to be awarded.

North Carolina State College now has an agreement with University Microfilms, Inc. of Ann Arbor, Michigan by which all doctoral dissertations are microfilmed and abstracts of the dissertations are published in *Dissertation Abstracts*.

Examinations.—Not earlier than the end of the second year of graduate study and not later than the end of the third week of the academic year in which the degree is expected each doctoral student is required to pass general comprehensive examinations (known as the qualifying or preliminary examinations). The examinations are given by an examining committee of graduate faculty members appointed by the Graduate Dean after consultation with the head of the department in which the student's major work has been taken. The examining committee usually consists of the student's advisory committee and a representative of the Graduate School, but may include other members of the Graduate Faculty. The examinations are open to all members of the Graduate Faculty who may care to attend.

Authorization for the qualifying examination is requested of the Graduate School by the chairman of the student's advisory committee when the major

part of the student's program of course work has been completed and when, in the judgment of the committee, the student is prepared to devote the greater part of his time to the prosecution of his research study. Members of the examining committee will be notified of their appointment by the Graduate Office. Official printed forms will be supplied to the chairman of the examining committee for a report of the results of the examination.

The examination consists of two parts: (1) written examinations prepared separately by each member of the examining committee and (2) an oral examination held before the entire examining committee. Upon receiving authorization for holding the qualifying examination, the chairman of the examining committee will request examination questions from each member of the examining committee. Each set of questions will be given to the student by the chairman of the examining committee in any order that may seem appropriate. The questions together with the student's answers will be returned to the members of the committee for grading. The questions may cover any phase of the course work taken by the student during the period of his graduate study or any subject logically related and basic to an understanding of the subject matter of the major and minor areas of study. They should be designed to measure the student's mastery of these subject matter fields and the adequacy of his preparation for research investigations.

Upon satisfactory completion of the written examinations the student must pass an oral examination before the entire examining committee. This examination usually follows the written examination within a week. The members of the examining committee will be notified by the Graduate School of the time and place arranged for the oral examination. The oral examination is designed to test the student's ability to relate factual knowledge to specific circumstances. In the oral examination the student is expected to use his knowledge with accuracy and promptness and to demonstrate that his thinking is not limited to the facts learned in course work.

When the examining committee consists of five members, a unanimous vote of approval is required for passing the preliminary examination. Approval may be conditioned, however, upon the completion of additional work in some particular field to the satisfaction of the committee. In case a single dissenting vote is cast in a five member committee, the course of action to be taken will become a matter for decision by the Administrative Board. Upon receiving the approval of the examining committee the student is admitted to candidacy for the doctorate.

A final oral examination is also required. During a normal academic year, an interval of at least eight months must elapse between admission to candidacy and the final oral examination. If summer sessions are involved, this interval may be interpreted to include two consecutive summer sessions and one academic semester.

This examination is held after the dissertation has been completed and consists in a defense by the candidate of the methods used and the conclusions reached in his research study. The examination is conducted by an examining committee. The examining committee usually consists of the student's advisory committee, plus a representative of the Graduate School, although this procedure is not always adopted. The examining committee is

appointed by the Graduate Dean after consultation with the head of the student's major department.

The final oral examination may not be held until the dissertation in complete and final form, bearing the signature of the chairman of the student's advisory committee as evidence of committee approval has been submitted to the Graduate Office.

Failure of a student to pass either the preliminary or the final examination terminates his graduate work at this institution unless otherwise recommended by the examining committee. No re-examination may be given until at least one full semester has elapsed since the first examination. Only one re-examination is permitted.

Admission to Candidacy.—A student is admitted to candidacy upon successfully passing the preliminary examinations. The language requirements must be fulfilled before permission to take the preliminary examination will be granted. Admission to candidacy must be obtained before the end of the third week in the academic year in which the degree is expected; i.e., nearly two semesters before the degree is awarded.

Thesis Regulations.—A booklet containing detailed instruction about the form of dissertation may be obtained at the Graduate Office.

Further information about graduate work at State College may be secured from Walter J. Peterson, Dean of the Graduate School, N. C. State College, Raleigh, N. C.

SUMMARY OF PROCEDURES FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

1. Letter of inquiry from prospective student to Graduate Office or Department Head.
2. Mailing of proper forms to student by Graduate Office or Department Head.
3. Receipt of application forms by Graduate Office.
4. Application with transcript sent to Department Head for study.
5. Department Head recommends acceptance of prospective student stating curriculum in which he will work.
6. Assuming the prospective student meets the minimum scholastic standards, notice of acceptance is mailed to him by the Graduate Office.
7. Permit to register is sent by Graduate Office to the Registrar.
8. Student arrives, reports to the Department Head, is assigned an advisor, and makes out a roster of courses in consultation with departmental advisor.
9. Advisory committee of at least five members is appointed in the first term of graduate study by the Graduate Dean after consultation with the Department Head.
10. Plan of work prepared by the advisory committee in consultation with the student and submitted in quadruplicate to the Graduate Office by the end of the first semester in residence.
11. Plan of work approved by the Graduate Dean and three copies returned to the Department Head. One copy is kept in department files, one goes to the advisor, and one is given to the student.

12. A dissertation subject is selected and an outline of the proposed research submitted to the Department Head and the student's advisory committee.
13. Student passes language examinations.
14. The chairman of the student's advisory committee requests permission to hold the qualifying examination. This must be done not earlier than the end of the second year of graduate study and not later than 8 months before the date on which the degree is to be awarded.
15. Permission to take qualifying examination granted by Graduate Dean if the student's record is in order. A date is set and examining committee appointed. The examination consists of two parts—a written and an oral.
16. A report of the examination is sent to the Graduate Office. If favorable, the student is admitted to candidacy.
17. A copy of a preliminary draft of the dissertation is submitted to the chairman of the student's committee for criticism.
18. Corrected draft of the dissertation submitted to members of the student's advisory committee for additional suggestions and criticisms.
19. Three copies of the dissertation in final form approved by each member of the students advisory committee and signed by the advisor are submitted to the Graduate Office *at least six week prior to awarding of the degree.*
20. Eight months after admission to candidacy or later, permission for the candidate to take the final oral examination is requested of the Graduate School by the chairman of the candidate's advisory committee. Requests should be filed at least one week before the date of the examination.
21. Permission granted by Graduate Dean if the student's record is in order. A date is set and examining committee appointed.
22. Report of the examination sent to the Graduate Office at least one week prior to the date on which the degree is to be awarded.
23. Graduate Office certifies to the Registration Office and to the General Faculty that all requirements for the degree have been met and recommends the awarding of the degree.
24. Student must be registered in the term in which the degree is to be awarded.

TUITION AND FEES FOR GRADUATE STUDENTS

FIRST SEMESTER

Course Load	In-State Students			Out-of-State Students		
	Fees*	Tuition	Total	Fees*	Tuition	Total
7 cr. hrs. or more	\$71.00	\$75.00	\$146.00	\$71.00	\$250.00	\$321.00
6 cr. hrs. or less	54.50	37.50	92.00	54.50	125.00	179.50
3 cr. hrs. or less	46.25	18.75	65.00	46.25	62.50	108.75

SECOND SEMESTER

Course Load	In-State Students			Out-of-State Students		
	Fees*	Tuition	Total	Fees*	Tuition	Total
7 cr. hrs. or more	\$65.00	\$75.00	\$140.00	\$65.00	\$250.00	\$315.00
6 cr. hrs. or less	48.50	37.50	86.00	48.50	125.00	173.50
3 cr. hrs. or less	40.25	18.75	59.00	40.25	62.50	102.75

*The Athletic Fee of \$10 in the first semester and \$5 in the second semester will be refunded if the student presents his identification card to the business office within 10 days after the date of registration.

Students who are not living in the campus area and whose professional responsibilities prevent their participation in the activities supported by the non-academic fees will be exempt from payment of non-academic fees.

Assistantships: Graduate students who have received appointments as teaching or research assistants will be charged, during the period of their employment, the tuition rates paid by residents of North Carolina.

Thesis Preparation: Graduate students who have completed all course work and residence requirements and who are in residence for the purpose of writing a thesis or dissertation may register for "thesis preparation." The tuition charge for this registration is \$15. Students registering for thesis preparation will pay all non-academic fees (athletic fees are optional.)

Graduate students, not in residence, who have completed all requirements for the degree sought including the thesis and final examination will be required to register for "Degree Only" in the term in which the degree is awarded. The charge for this registration will be \$10.

Audits: Students wishing to visit classes without participation in class discussions, quizzes or examinations must register for this privilege as auditors. Visiting classes without registration is not permitted. Graduate students may register for one course as audit in any semester without charge when the audit forms a part of course work for which tuition charges are made. Audits in subjects in which the student has had no previous experience will be evaluated at full credit value in determining course loads. Audits taken as repetition of work previously accomplished are considered at one half their credit value in calculating course loads. With the single exception of foreign language audits, all audit registrations must fall within the maximum permissible course loads. Audits are not permitted students registering for thesis preparation.

While audit registrations are evaluated for purposes of determining permissive course loads in terms of the above regulations by the Graduate Office, the Business Office considers all audits, excepting the one permitted free of charge, in terms of full credit value in calculating the fees for graduate students.

Diploma Fee: A diploma fee of \$12 is charged all students receiving a master's degree and a fee of \$17 is charged all students who receive a doctorate. A fee of \$21 is charged all doctoral candidates for microfilming their dissertations.

All tuition charges and fees are subject to change without notice.

FEES FOR SUMMER SCHOOL

Registration Fee	\$11.00
Tuition (In-State Students per credit hour)	7.50
Tuition (Out-of-State Students per credit hour)	15.00
Audits (per course)	7.50

In order to draw a clear line between in-state and out-of-state students, the Administration has ruled that all students whose parents have not been domiciled in North Carolina for more than six months immediately preceding the day of their first enrollment in the institution shall be termed out-of-state students, with the following exceptions:

- (1) Students twenty-one years of age at the time of their first matriculation who have resided in North Carolina for more than one year preceding the day of their first enrollment;
- (2) Children of regular employees of the Federal Government stationed in the State of North Carolina; and
- (3) Children of regular employees of the Federal Government who are employed outside of the State, but who through law are permitted to retain their North Carolina citizenship.

Students cannot claim a change in their resident status after matriculating. Students furnishing incomplete or incorrect information in order to obtain the special State-resident status shall be liable for dishonorable dismissal.

Graduate students employed by the College or the Experiment Station on a part-time basis are not permitted to register for a full-time load of course work. The Veterans Administration will classify such students as full-time students when it is officially certified by the Dean of the Graduate School that the student is engaged in a full-time program of professional work.

Fellowships and Graduate Assistantships

Graduate Fellowships are funds offered to graduate students to assist in the support of programs of advanced study. Holders of fellowships have no service obligations to the College and may devote full time to the prosecution of their graduate programs.

Some of the agencies sponsoring fellowships at North Carolina State College are: The Celanese Corporation, DuPont Company, Eastman Kodak Company, Edward Orton, Jr. Ceramic Foundation, General Foods Corporation, Honor Society of Phi Kappa Phi, Mortex Chemical Products, N. C. Grange (E. G. Moss Fellowship), Sperry Gyroscope Company, Union Carbide Corporation and Westinghouse.

Information relative to stipends, areas of research study supported by

specific fellowships and application forms may be obtained from the Graduate School or from the heads of the appropriate departments.

Graduate Assistantships are granted to selected students who devote some part of their time to service duties for the College. Teaching assistantships carry a stipend of \$2,400 for the academic year and permit the holder to enroll for sixty per cent of a full course load. The stipends for research assistantships range from \$2,000 to \$2,400 for a 12 months' appointment. The college offers 250 assistantships which require a service obligation in either teaching or research. Some of these are supported by funds granted by the following agencies: the American Potash Institute, the Atomic Energy Commission, the Chilean Nitrate Education Bureau, Inc., Hercules Powder Company, the Lilliston Implement Company, the Lilly Company, the McLean Trucking Company, the North Carolina Department of Motor Vehicles, the North Carolina State Optometric Society, the Office of Naval Research, the Pacific Coast Borax Company, the Ralston-Purina Company, the Tennessee Corporation, the Solvay Process Division of the Allied Chemical Company, and the Union Carbide Chemicals Company.

Residence Facilities

Dormitory facilities are provided on the campus for unmarried graduate students. The rental charge for double rooms is \$85 per semester. A limited number of apartments are provided for married graduate students.

DESCRIPTION OF COURSES

The courses described on the following pages are planned for the academic years, 1960-61 and 1961-62 unless otherwise indicated. Specific courses may not be offered, however, if registration for the course is too low or if faculty or facilities become unavailable.

Courses for which graduate credit may be received are numbered in three categories. Courses with a number in the 400 series carry no graduate credit when they fall in the student's major field of interest. Graduate credit will be allowed for no more than 6 semester hours at the 400 level in the student's minor area of study.

Courses bearing a number in the 500 series are open to both seniors and graduate students. All courses in this series carry full graduate credit.

Courses given a 600 series number are open only to graduate students.

AGRICULTURE

AG 401. Principles and Methods of Extension Education 0-3
A study of the background, development, and operation of the Agricultural Extension Service. Consideration is given to major events leading to the establishment of Agricultural Extension, its objectives, organization, and philosophy. Major emphasis is placed upon the principles underlying Extension education together with methods of program building and teaching.
Mr. Sloan

DEPARTMENT OF AGRICULTURAL ECONOMICS

Graduate Faculty

Professors: CHARLES EDWIN BISHOP, HEAD, H. BROOKS JAMES, RICHARD ADAMS KING, JAMES GRAY MADDOX, WALTER HENRY PIERCE, GEORGE STANFORD TOLLEY.

Associate Professors: ARTHUR JAMES COUTU, WILLIAM RAY HENRY, WILLIAM DOUGLAS TOUSSAINT, JAMES CLAUDE WILLIAMSON, JR.

The Department of Agricultural Economics offers programs of study leading to the Master of Agricultural Economics, the Master of Science and the Doctor of Philosophy degrees. Special emphasis is placed on the economics of agricultural production and marketing, analysis of programs and policies affecting agriculture and statistical techniques used in solving economic problems of the agricultural industry. The curriculum includes courses in advanced economic theory with special adaptation to agricultural problems including the use of econometric and linear programming techniques. Business management analysis, operations analysis and programming of firm and industry decisions are emphasized. Special attention is given to public policies influencing regional and national agricultural adjustments.

Collateral fields of study include statistics, rural sociology, history and political science, general economics, agricultural education and various technical departments of the School of Agriculture.

As a part of their advanced training, students are required to prepare a thesis dealing with a recognized problem in agriculture. This part of the program affords an opportunity to learn how to apply theory and analytical techniques in the solution of agricultural problems.

The rapid growth and development of industry and agriculture in North Carolina and throughout the South have resulted in an increased demand for well-trained workers throughout the region. This demand far exceeds the number of qualified workers available to perform the many duties associated with the complex and technical problems of a developing economy. Many graduates of the Department of Agricultural Economics are employed in various agencies of the Federal and State governments engaged in research and educational work. Others are engaged in professional work with commercial organizations dealing in agricultural credit and the production and marketing of agricultural products.

The Department is located on the second floor of Patterson Hall. It has a modern and well equipped departmental library, including all the major professional journals and USDA publications. Experiment Station publications from other institutions throughout the United States are kept on file. In addition to modern computational and reproduction equipment available in the Department, an IBM 650 digital computer and a Rand 1105 computer are available to the Department.

Courses for Advanced Undergraduates

AGC 413. Farm Appraisal and Finance

0-3

Prerequisite: AGC 303.

The principles of farm appraisal and practical methods used in determining the value of farms of various types and sizes; credit financing in agriculture, including (1) types, sources, and cost of credit, (2) repayment plans, and (3) methods of determining when and how credit can be used effectively by farmers; special problems associated with agricultural credit.

Staff

Prerequisite: AGC 212.

This course involves an examination of the behavior of agricultural prices as related to decision-making of economic units. Emphasis is placed on the interpretation of price information in relation to income, consumption and production of farm products. Consideration is given to marketing practices which influence price formation in the exchange of agricultural products. Methods of agricultural price analysis, including construction and use of index numbers, and measures of various types of price movements are studied.

Messrs. Pierce and Hoover

Courses for Graduate Students and Advanced Undergraduates

AGC 501. (EC 501). Intermediate Economic Theory 3 or 3

An intensive analysis of the determination of prices and of market behavior, including demand, costs and production, pricing under competitive conditions, and pricing under monopoly and other imperfectly competitive conditions.

Staff

AGC 512. Economic Analysis of Agricultural Factor Markets 0-3

Prerequisite: AGC 212.

This course is oriented to the relative significance of land, labor and capital as factors of production in a modern agricultural economy, including major changes in the respective roles of these factors of production in recent years. An examination is made of the changes in characteristics of the supply and demand for these factors. The structure and efficiency of markets for these factors, including relevance of the institutional and attitudinal setting in each type of market, and nature of the demand-supply equilibration will be investigated. Public policies as they affect efficiency of the factor markets and other goals relating to the use of the basic factors of production in agriculture also will be considered.

Mr. Tolley

AGC 521. Agricultural Market Analysis 0-3

Prerequisite: AGC 311, or equivalent.

A study of marketing firms as producers of marketing services and their role in the pricing process; the influence of government policies on the behavior of marketing firms; methods for increasing the efficiency of marketing agricultural products.

Mr. King

AGC 523. Planning Farm and Area Adjustments 3-0

Prerequisite: AGC 303, or equivalent.

The application of economic principles in the solution of production problems on typical farms in the state; methods and techniques of economic analysis of the farm business; application of research findings to production decisions; development of area agricultural programs.

Mr. Coutu

AGC 533. Agricultural Policy 0-3

Prerequisite: AGC 212.

A review of the agricultural policy and action programs of the Federal Government in their economic and political setting; analysis of objectives, principal means, and observable results under short-term and long-term viewpoints, and under the criteria of resource use and income distribution within agriculture, and between agriculture and the rest of the economy; appraisal of alternative policy proposals; the effects of commodity support programs on domestic and foreign consumption, and some

of the international aspects of United States agricultural policy; the attempts at world market regulations, and the role of international organizations, agreements, and programs. Mr. Williamson

AGC 551. Agricultural Production Economics 3-0
Prerequisite: AGC 212.

An economic analysis of agricultural production, including: production functions, cost functions, programming and decision-making principles; and the applications of these principles to farm and regional resource allocation, and to the distribution of income to and within agriculture.

Mr. Toussaint

AGC 552. Consumption, Distribution and Prices in Agriculture 0-3
Prerequisite: AGC 212.

Basis for family decisions concerning consumption of goods and services and supply of productive factors; forces determining prices and incomes; interrelationships between economic decisions of the household and the farm.

Mr. Henry

AGC 561. Seminar in Contemporary Economic Problems in Agriculture Max. 6

Prerequisite: Senior or graduate standing and consent of the instructor.

Analysis of economic problems of current interest in agriculture. Credit for this course will involve a scientific appraisal of a selected problem and alternative solutions.

Staff

Courses for Graduate Students Only

AGC 602. Monetary and Fiscal Policies in Relation to Agriculture 0-3
Prerequisite or corequisite: AGC 501, or equivalent.

The essentials of monetary theory necessary in interpreting and evaluating monetary and fiscal operations and policies as to their effect upon income, employment, and price level; the monetary and fiscal structure, and the mechanics of monetary and fiscal operations in the United States; and the relation of monetary and fiscal policies to agricultural income and prices.

Messrs. Tolley and Williamson

AGC 612. International Trade in Relation to Agriculture 0-3
Prerequisite or corequisite: AGC 602 and 641.

The principles of international and interregional trade; structures of trade relationships between countries engaged in the import or export of agricultural products; attempts at stabilizing trade and financial transactions.

Mr. Tolley

AGC 621. Research in Agricultural Economics Credits by arrangement

Prerequisite: Graduate standing in Agricultural Economics, and consent of Graduate Advisory Committee.

A consideration of research methods and procedures employed in the field of agricultural economics, including qualitative and quantitative analysis, inductive and deductive methods of research procedure, selection of projects, planning, and execution of the research project. Staff

AGC 631. Economic and Social Foundations of Agricultural Policy 3-0

Prerequisite: AGC 501, or equivalent.

The study of logical and empirical problems of inquiry into public policies and programs that affect agriculture; analysis of policy-making processes, interdependencies among economic, political and social objectives and action; the study of forces which shape economic institutions and goals and of the logic, beliefs and values on which policies and programs that affect agriculture are founded.

Mr. Lindsey

AGC 632. Welfare Effects of Agricultural Policies and Programs 3-0

Prerequisite: AGC 642.

Description of the conditions defining optimal resource allocation; application of the conditions for maximum welfare in appraisal of economic policies and programs affecting resource allocation, income distribution, and economic development of agriculture.

Mr. Bishop

AGC 641. Economics of Production, Supply and Market Interdependency

3-3

Prerequisite or corequisite: AGC 501, or equivalent.

An advanced study in the logic of, and empirical inquiry into: producer behavior and choice among combinations of factors and kinds and quantities of output; aggregative consequences of individuals' and firms' decisions in terms of product supply and factor demand; factor markets and income distribution; general interdependency among economic variables.

Messrs. Seagraves and Williamson

AGC 642. Economics of Consumption, Demand, and Market Interdependency 0-3

Prerequisite: AGC 641 and ST 513 or equivalent.

An advanced study in the theory of, and research related to, household behavior; aggregative consequences of household decisions concerning factor supply and product demand; pricing and income distribution; economic equilibrium.

Mr. King

AGC 651. (ST 651) Econometric Methods I 0-3

Prerequisites: St 514, ST 521, and AGC 642.

Decision-making under uncertainty; stochastic elements in economic theories; problems of model construction; special techniques for analyzing simultaneous economic relations.

Graduate Staff

AGC 652. (ST 652) Econometric Methods II 3-0

Prerequisites: ST 522, and AGC 641.

Basic concepts of estimation and tests of significance as applied to economic data; empirical sampling methods; non-parametric methods; sequential testing; extension of least squares methods to research in economics; production surfaces; special topics in variance components and mixed models; use of experimental designs in economic research; elements of multivariate analysis; techniques for analysis of time series.

Graduate Staff

AGC 671. Analysis of Economic Development in Agriculture 3-0

Prerequisite: AGC 641.

A theoretical and empirical study of the processes of economic growth; the problems of under developed countries; the role of agriculture in a developing economy; an examination of policies and programs needed for effective economic development.

Mr. Maddox

DEPARTMENT OF AGRICULTURAL EDUCATION

See Education.

DEPARTMENT OF AGRICULTURAL ENGINEERING

Graduate Faculty

Professors: GEORGE WALLACE GILES, Head, FRANCIS JEFFERSON HASSLER, In Charge, Agric. Engr. Graduate Studies, DAVID S. WEAVER
Associate Professors: HENRY DITTIMUS BOWEN, WILLIAM ELDON SPLINTER, JAN VAN SCHILFGAARDE

The Department of Agricultural Engineering offers advanced study leading to the Ph.D. degree in any one of five fields of specialization: Power and Machinery, Rural Structures, Soil and Water Conservation, Rural Electrification, or Agricultural Processing.

The Master of Science program in Agricultural Engineering provides a broad background in science and engineering through advanced study in Mathematics and Physics. It offers training in the theoretical and instrumental aspects of engineering research and development as preparation for teaching and research positions with State and Federal institutions and industry.

For those individuals interested primarily in existing technologies, a program of study for the Master of Agricultural Engineering degree permits selections from a variety of advanced application courses. This program provides training appropriate for those engaged in the dissemination of information either as extension workers with public institutions or sales and service representatives for industry, but it is not intended as preliminary study to the Ph.D. degree.

Extensive research programs, in the mechanization of cotton, peanuts and tobacco, in the curing and drying of forage crops, peanuts and tobacco as well as in irrigation and land drainage and in other subjects under way in the Department offer unusual opportunities for graduate student research. The Department maintains a complete research shop manned by competent mechanics available to graduate students.

Admission to full graduate standing requires a Bachelor's degree in Agricultural Engineering from an accredited curriculum or its equivalent.

Courses for Advanced Undergraduates

AGE 401. Farm Shop Organization and Management

3-3

Prerequisites: AGE 201 and 202.

The use and care of power tools; planning of school shops and laboratories; selection of tools, materials, and equipment; shop management; and methods of presenting the subject matter.

Messrs. Howell, Blum

AGE 411. Farm Power and Machinery 11B

3-0

Prerequisite: AGE 211.

This course is designed to provide students in Mechanized Agriculture with a knowledge of the operations of manufacturing and distributing organizations of farm machinery and their places in those organizations.



New Agricultural Engineering Building under construction



Facilities for investigation of biophysical relationships pertinent to the engineering of agricultural productions.



High-speed photography for dynamic analysis of machine components.

Included is a practical course in farm tractors and engines with emphasis on familiarizing the student with component parts—their application, operation, and maintenance, as well as with the selection of these units from the standpoint of power, performance, and ratings.
Messrs. Fore, Greene

AGE 451. Curing and Drying of Farm Crops.

2-0

Prerequisite: ME 301.

Physical properties of air, fuels, and crop products as applied to the design of systems for the removal of moisture from crops. Problems involved in handling and storage in conjunction with driers.
Staff

AGE 452. Senior Seminar

1 credit per semester

Students will prepare talks in their particular fields of interest, presenting them to the group. Also, two or three field trips to selected points of educational opportunities will be made during the second semester. Maximum of two credits allowed. Mr. Giles and Staff

AGE 462. Farm Power and Machinery IIA

4-0

Prerequisites: AGE 211, EM 321 (Strength of Materials)

A study of the basic principles underlying the functional elements of farm machinery including analysis of operation, functions of various components, basic studies of processes, and the service adjustment and operation of current farm equipment. The course also includes a fundamental study of internal combustion engines and power trains to the various outlets; basic designs and applications of farm tractors including hitches, power lifts, and other integral parts.
Mr. Bowen

AGE 481. Farm Structures

0-3

Prerequisites: AGE 451 and EM 321.

Space and grouping arrangements, material use, and construction techniques to gain optimum efficiency, use and satisfaction from buildings on the farm. The design of walls and wall coverings to impair the transfer of heat and moisture. The design of building elements and their connections to withstand their imposed loads.
Staff

AGE 491. Rural Electrification

4-0

Prerequisite: EE 320 (Elements of Electrical Engr.)

A study of the history and development of rural electrification, rates and costs of serving the farm with electricity; farm wiring and lighting; electric motors; water systems; feed grinding and other applications of electricity to farming. Also included for study are materials and design for rural distribution lines; switches and controls; heat and refrigeration; poultry and dairy equipment; and other applicable uses of electricity in farm processes.
Mr. Weaver

Courses for Advanced Undergraduates and Graduates

AGE 551 Special Problems

Credits by Arrangements

Prerequisite: Senior or Graduate standing in Ag. Engr.

Each student will select a subject on which he will do research and write a technical report on his results. He may choose a subject pertaining to his particular interest in any area of study in Agricultural Engineering.

Mr. Giles and Staff

AGE 552. Instrumentation for Agricultural Research and Processing

1-0

Prerequisite: EE 320, MA 401.

The functions of resistor, capacitor and inductor are described on the theories of electron distribution and displacement. These circuit components plus thermionic tubes are combined analytically to provide basic circuits for rectification, amplification and oscillation. The principles of various primary sensing elements are related to their use as transducers. A study of representative equipment for indicating, recording and controlling process variables concludes this course.
Mr. Hassler.

Courses for Graduates Only

AGE 651. Research in Agricultural Engineering

Credits by Arrangement

Prerequisite: Graduate standing in Agricultural Engineering.

A maximum of six credits is allowed toward a Masters degree; no limitation on credits for Doctorate program.

Performance of a particular investigation of concern to Agricultural Engineering. The study will begin with the selection of a problem and culminate with the presentation of a thesis.

Graduate Staff

AGE 652. Seminar

1-1

Prerequisite: Graduate standing.

A maximum of two credits is allowed.

Elaboration of the subject areas, techniques and methods peculiar to professional interest through presentations of personal and published works; opportunity for students to present and defend, critically, ideas, concepts and inferences. Discussions to point up analytical solutions and analogies between problems in Agricultural Engineering and other technologies, and to present the relationship of Agricultural Engineering to the socioeconomic enterprise.

Mr. Hassler

AGE 654. Agricultural Process Engineering

3-3

Prerequisites: AGE 451, PY 401, MA 511.

Generalized classical thermodynamics is extended by Onsager's relations to provide a theoretical basis for analyzing the energetics of systems that include life processes.

Mr. Hassler

AGE 661. Analysis of Function and Design of Farm Machinery

3-3

Prerequisites: AGE 462; MA 401; Statistics, PY 401.

Methods and tools used in determining the functional requirements of machine components; writing of machine specifications in terms of fundamental parameters; introduction of the principles of discriminate and indiscriminate mechanical selection of agricultural products with emphasis on the theory of servo-systems.

Mr. Bowen

AGE 671. Theory of Drainage, Irrigation and Erosion Control

4-4

Prerequisites: AGE 371; EM 430; MA 401.

Emphasis is placed on the physical and mathematical aspects of problems in conservation engineering and an attempt is made to rationalize procedures which have often come about through experience rather than through analytical considerations. Examples are presented of cases where such an analytical approach has already improved, or shows promise of improving, design criteria and procedures.

Mr. Van Schilfgaarde

AGE 681. Analysis of Function and Design of Farm Buildings

4-4

Prerequisites: AGE 481; PY 402.

A study of the functional requirements of farm structures with respect to man, animals, and crops and development of the means for providing structures which fulfill the functional requirements. Application of the

science and art of engineering in the solution of environmental problems. Advanced planning in the integration of structural and environmental design.

Staff

DEPARTMENT OF AGRONOMY

See Departments of Field Crops and Soils

DEPARTMENT OF ANIMAL INDUSTRY

Graduate Faculty

Professors: GEORGE HYATT, JR., Head, ELLIOTT ROY BARRICK, EDWARD GUY BATTE, THOMAS NELSON BLUMER, DEAN W. COLVARD, JOHN LINCOLN ETHELLES, JAMES EDWARD LEGATES, GENNARD MATRONE, JOHN CLARK OSBORNE, WILLIAM MILNER ROBERTS, MARVIN LUTHER SPECK, HAMILTON ARLO STEWART, WALTER E. THOMAS, GEORGE HERMAN WISE.

Professor Emeritus: FRANCIS WEBBER SHERWOOD.

Associate Professors: LEONARD WILLIAM AURAND, THOMAS A. BELL, JAMES GIACOMO LECCE, W. RAY MURLEY, FRANK HOUSTON SMITH, SAMUEL B. TOVE, LESTER CURTISS ULBERG, FREDERICK GAIL WARREN.

Assistant Professors: ALBERT J. CLAWSON, E. U. DILLARD, LEMUEL GOODE, JOHN JOSEPH MCNEILL, RICHARD DOUGLAS MOCHRIE, HAROLD ARCH RAMSEY, W. W. G. SMART, JR., MILTON B. WISE.

The Department of Animal Industry offers the Master of Science and the Doctor of Philosophy degrees in Animal Industry and in Dairy Manufacturing. The degrees in Animal Industry provide for major programs of work in the fields of animal breeding, animal husbandry, dairy husbandry, animal nutrition, and animal diseases.

Students majoring in Animal Husbandry may select options in meat preservation and processing, rumen physiology, meat animal nutrition, and other phases of Animal Husbandry.

Dairy Husbandry majors have options in dairy cattle nutrition, physiology of lactation, rumen physiology and other phases of dairying.

For Animal Nutrition majors, specialized work is offered in mineral metabolism, intermediary metabolism, vitamins, rumen microbiology, and other fundamental phases of Animal Nutrition involving either laboratory animals or livestock.

Students with majors in Animal Diseases are offered specialized work in pathology, parasitology, veterinary bacteriology and virology, and other phases of animal diseases.

Students in Animal Breeding may major in physiology of reproduction and quantitative animal genetics.

Degrees in Dairy Manufacturing provide for programs of work in dairy chemistry, dairy bacteriology, dairy products and dairy plant management.

In cooperation with other departments, such as Poultry, Statistics, Field Crops, Soils, and Chemistry, specialized subject matter groups have been developed to direct graduate work in fields such as Animal Genetics and fundamental phases of Animal Nutrition. Strong supporting departments

in Statistics, Chemistry and the Biological Sciences help provide the opportunities for a broad and thorough graduate training.

Facilities—The Department operates approximately 2,000 acres of land in order that animals of various types and breeds may be available for research. In addition, branch stations are located in all major geographic areas of the state so that the research program may be applied to the conditions existing throughout the state. The Animal Industry Research Center, which is located adjacent to the campus, serves as an intermediary between the farms and the laboratories on the campus. At this Research Center, digestion trials, animal disease research and many phases of the physiology and nutrition programs are conducted. In addition, a physiology laboratory and bull barn, with stalls for 20 bulls and with two temperature control chambers, is used for research in physiology of reproduction and dairy cattle breeding.

The Department of Animal Industry, with the exception of the Veterinary Section, is housed in Polk Hall, a three story building located near the center of the campus. The dairy and the meat processing plants and laboratories, as well as research laboratories for animal nutrition, radioactive isotope studies, animal physiology, animal breeding, dairy bacteriology, and dairy chemistry are located in this building. Other facilities include classrooms, a scientific journal reading room, and offices for the various teaching, research, and extension staff members.

The Veterinary Section is located in a new and modern animal disease laboratory building, which provides excellent facilities for research and teaching in the animal disease field. Included are large animal isolation units for work in the field of veterinary bacteriology and virology, parasitology, physiology, and bacteriology research laboratories and a diagnostic laboratory and necropsy room.

Every effort is made to provide an opportunity for the graduate student to explore the fundamental principles of livestock production and of product processing. The graduate student roster is composed of men and women from many states and several countries. The staff is composed of men who received their training at various institutions.

The staff and the physical facilities in various sections are adequate to provide leadership and training for an enrollment of approximately 50 graduate students.

Opportunities—

Those receiving advanced degrees have found employment in other educational and research institutions, in dairy manufacturing organizations, in meat processing industries, in feed manufacturing businesses and in other fields. In the past the demand for well-trained personnel has exceeded the number that has been available.

Courses for Advanced Undergraduates

AI 401. Beef Cattle Production

3 or 3

Prerequisite: AI 202.

Fundamental principles of the production of beef; selection, feeding and management of breeding herds and feeder cattle.

AI 402. Sheep Production	0-3
Prerequisite: AI 202.	
Study of the factors involved in the feeding, breeding, management and marketing of lamb, mutton and wool.	Mr. Goode
AI 403. Pork Production	3 or 3
Study of production, management and marketing practices involved in the successful production of swine.	Mr. Clawson
AI 404. Dairy Farm Problems	0-3
Prerequisite: AI 201.	
Advanced study of practical dairy farm management including farm records, farm buildings, sanitation, roughage utilization and herd culling.	Mr. Murley
AI 406. Animal Industry Seminar	0-1
Review and discussion of special topics and the current literature pertaining to all phases of Animal Production.	Mr. Hyatt

Courses for Graduates and Advanced Undergraduates

AI 501. Physiology of Domestic Animals	4-0
Prerequisite: ZO 301.	
A course in advanced physiology of domestic mammals with special reference to farm animals.	Messrs. Ulberg, Thomas, and Wise
AI 502. Reproduction and Lactation	0-4
Prerequisite: ZO 301.	
Anatomy and physiology of the reproductive organs and mammary gland with detailed coverage of physiological processes involved and factors controlling and influencing them. Specific applications to farm animals including artificial insemination.	Messrs. Mochrie, and Ulberg
AI 503. (GN 503). Genetic Improvement of Livestock	3-0
Prerequisite: GN 411.	
Traits of economic importance in livestock production, and their mode of inheritance. Phenotypic and genetic relationships between traits. The place of selection, inbreeding and cross breeding in a program of animal improvement.	Mr. Robison
AI 505. Diseases of Farm Animals	3-0
Prerequisites: CH 101, CH 203; BO 421 desired.	
The pathology of bacterial, viral, parasitic, nutritional, thermal and mechanical disease processes.	Mr. Osborne
AI 507. Topical Problems in Animal Industry	Max. 6
Special problems may be selected or assigned in various phases of Animal Industry. A maximum of six credits is allowed.	Staff
AI 513. Needs and Utilization of Nutrients by Livestock	0-3
Prerequisite: AI 312 or equivalent.	
Measurement of nutrient needs of livestock and the nutrient values of feeds. Nutritive requirements for productive functions.	Mr. Wise

Courses for Graduates Only

AI 600. Research in Animal Industry	Credits by arrangement
A maximum of six hours is allowed toward the Master's degree; no limitation on credits in Doctorate programs.	Graduate Staff

- AI 601. Seminar in Animal Nutrition** 1-1
 Prerequisite: Permission of seminar leaders.
 Orientation in philosophy of research, organization for research and general research methodology. Graduate Staff
- AI 602. (GN 602). Population Genetics in Animal Improvement** 3-0
 Prerequisites: ST 512, GN 512.
 A study of the forces influencing gene frequencies, inbreeding and its effects, and alternative breeding plans. Mr. Legates
- AI 603. Animal Nutrition: Mineral Metabolism** 3-0
 Prerequisite: CH 551.
 Role of minerals in the nutrition of animal with emphasis on available knowledge, a digest of progress already made and directions in which investigations need to be extended. Mr. Matrone
- AI 614. (BO 614) Physiology of Microorganisms.** 0-3
 Prerequisites: BO 412, CH 551.
 A study of the physical structure and chemical composition of microorganisms; the influence of physical and chemical agents on growth and reproduction; the metabolism of carbohydrates, proteins and lipids. Mr. McNeill
- AI 621. (CH 621) Enzymes and Intermediary Metabolism** 4-0
 Prerequisites: CH 551 and permission of instructor.
 A study of the properties of enzymes and enzyme action; intermediary metabolism of carbohydrates, lipids, fatty acids, vitamins, and porphyrins; metabolic energy relationships. Mr. Tove
- AI 622. (CH 622 and ST 622) Principles of Biological Assays** 0-3
 Prerequisites: CH 551, ST 512.
 Techniques and designs of biological assays. The interrelationship of logical principles design and analysis is emphasized. Messrs. Carter and Tove

DEPARTMENT OF BOTANY AND BACTERIOLOGY

Graduate Faculty

Professors: HERBERT T. SCOFIELD, Head, ERNEST A. BALL, HAROLD J. EVANS, LARRY A. WHITFORD

Professor Emeritus: BERTRAM W. WELLS.

Associate Professor: ERNEST O. BEAL.

Assistant Professors: ARTHUR W. COOPER, JAMES W. HARDIN, HEINZ SELTMANN, JAMES R. TROYER.

The department offers work leading to the Master of Science degree in the fields of plant physiology, ecology, anatomy, morphology, bacteriology and systematic botany. Graduate work in preparation for the Doctorate is offered in the fields of plant physiology, morphology, ecology and systematic botany.

The Department of Botany and Bacteriology is provided with physical facilities and equipment adequate for teaching and research in all phases

of its program. Of special note are the laboratory and greenhouse facilities for research in plant physiology, particularly in mineral nutrition, as well as the rapidly growing Herbarium which supports study in systematics and ecology. Recently acquired constant temperature growth chambers enhance research in all phases of experimental plant science.

Graduate students terminating their work at the Masters level have a somewhat limited opportunity as professional botanists. State and Federal employment is available as well as teaching positions in small colleges and secondary schools. Those achieving the Ph.D. degree, however, will find opportunities for teaching positions in colleges and universities, for research positions in federal and state Experiment Stations, and for research and development work in botanical fields with private industrial or research institutions.

Courses for Advanced Undergraduates

BO 403. Systematic Botany 0-3
Prerequisite: BO 103.

A systematic survey of vascular plants emphasizing field identification, terminology and general evolutionary relationships. Mr. Beal

BO 407. Dairy Bacteriology
(see DM 407).

BO 410. Plant Histology and Microtechnique 3-0
Prerequisites: BO 103, a course in organic chemistry.

Studies of the principal tissues of Angiosperms in terms of the theory and practice of optical instrumentation, microtechnical preparations, and photomicrography. Mr. Ball

BO 421. Plant Physiology 4 or 4
Prerequisites: BO 103, 2 courses in chemistry.

An introductory treatment of the chemical and physical processes occurring in higher green plants with emphasis upon the mechanisms, factors affecting, correlations between processes, and biological significance. Messrs. Scofield and Troyer

BO 441. Plant Ecology 3-0
Prerequisite: BO 103.

An introduction to the study of plants in relation to their environment. Major topics considered are: factors of the environment; the structure, analysis, and dynamics of plant communities; past and present distribution of vegetation types. Mr. Cooper

Courses for Advanced Undergraduates and Graduates

BO 506. Dairy Bacteriology II
(see DM 506)

BO 512. Morphology of Vascular Plants 3-0
Prerequisite: BO 103.

A study of comparative morphology, ontogeny and evolution of the vascular plants. Emphasis is placed upon the phylogeny of sexual reproduction and of the vascular systems. Mr. Ball

BO 513. Plant Anatomy 0-3
Prerequisite: BO 103.

A study of the anatomy of the Angiosperms and Gymnosperms. The development of tissues is traced from their origin by meristems to their mature states. Mr. Ball

BO 521. Systematic Botany of Monocot Families 3-0
Prerequisites: BO 103, 403.

A comprehensive survey of the systematics and evolution of monocot

families. Special emphasis is given to terminology, morphology, identification and relationships. Mr. Beal

BO 523. Systematic Botany of Dicot Families 3-0
Prerequisites: BO 103, 403.

A comprehensive survey of the systematics and evolution of dicot families. Special emphasis is given to terminology, morphology, identification and relationships. Mr. Hardin

BO 531. Soil Microbiology
(see SOI 532)

BO 532. Advanced Plant Physiology I 2-0
Prerequisite: BO 421 or equivalent.

An advanced treatment of water, solute, and gas relations of higher green plants, with emphasis on theoretical principles. Mr. Troyer

BO 533. Advanced Plant Physiology II 0-2
Prerequisite: BO 421 or equivalent.

An advanced treatment of metabolism and growth in higher green plants, with emphasis on theoretical principles. Mr. Troyer

BO 545. Advanced Plant Ecology 0-3
Prerequisites: BO 421, 441 or equivalents.

An advanced consideration, through class discussions and individual projects, of the principles, theories, and methods of plant ecology. Mr. Cooper

BO 570. Sanitary Microbiology
(see CE 570).

BO 574. Phycology 0-3
Prerequisite: BO 103 or equivalent.

A systematic study of the structure and classification of the algae, both fresh-water and marine. The life history and ecology of important local species will be emphasized. Mr. Whitford

Courses for Graduates Only

BO 603. Advanced Dairy Bacteriology
(see DM 603).

BO 614. Physiology of Microorganisms
(see AI 614).

BO 620. Advanced Taxonomy 0-3
Prerequisites: BO 521, 523 or permission of instructor.

A course in the principles of plant taxonomy including the history of taxonomy, systems of classification, rules of nomenclature, taxonomic literature, taxonomic and biosystematic methods, and monographic techniques. Mr. Hardin

BO 632. Advanced Soil Microbiology
(see SOI 632).

BO 635. The Mineral Nutrition of Plants

0-3

Prerequisites: BO 421 and a course in Biochemistry.

Discussion of the accumulation, translocation and utilization of mineral elements by higher plants. Emphasis will be placed on the relationships between these processes and plant metabolism. Mr. Evans

BO 640. Special Problems in Bacteriology

Credits by arrangement

Directed research in some specialized phase of bacteriology other than a thesis problem but designed to provide experience and training in research. Graduate Staff

BO 641. Research in Bacteriology

Credits by arrangement

Original research preparatory to writing a master's thesis or a Ph.D. dissertation. Graduate Staff

BO 650. Special Problems in Botany

Credits by arrangement

Directed research in some specialized phase of botany other than a thesis problem but designed to provide experience and training in research. Graduate Staff

BO 651. Research in Botany

Credits by arrangement

Original research preparatory to writing a master's thesis or a Ph.D. dissertation. Graduate Staff

BO 660. Bacteriology Seminar

1-1

Scientific articles, progress reports in research, and special problems of interest to bacteriologists are reviewed and discussed. Graduate student credit allowed if one paper per semester is presented at seminar.

Graduate Staff

BO 661. Botany Seminar

1-1

Scientific articles, progress reports in research, and special problems of interest to botanists are reviewed and discussed. Graduate student credit allowed if one paper per semester is presented at seminar.

Graduate Staff

CERAMIC ENGINEERING

See Department of Mineral Industries

DEPARTMENT OF CHEMICAL ENGINEERING

Professors: EDWARD MARTIN SCHOENBORN, Head, KENNETH ORION BEATTY, JR., FREDERICK PHILIPS PIKE.

Associate Professors: RICHARD BRIGHT, JOHN FRANK SEELY.

Assistant Professor: EUSTACE ROBINSON CONWAY.

The department offers programs of advanced study and research leading to the Master of Science and Doctor of Philosophy degrees. Currently, between twenty and twenty-five graduate students are in residence of which approximately one third are working toward the doctorate. The department comprises a highly competent staff which seeks to provide for intimate association between it and its students, to promote a common interest in

advanced professional study, and to encourage intensive investigation and creative activity of a high order.

For those who can qualify, graduate work in chemical engineering is of increasing importance since it enables the student to attain a higher degree of specialized professional competence and at the same time to secure greater mastery of the sciences which underlie the quantitative aspects of chemical technology. The demand for chemical engineers with advanced training is greater now than at any time since the birth of the great chemical industry. In fact, the number and variety of challenging opportunities is steadily increasing, especially in the South which is rapidly becoming the new industrial frontier. The recent high concentration of industries producing synthetic fibers and other materials within a radius of several hundred miles of the College is but one example of this development.

Students having had one or more years of training beyond the baccalaureate are especially needed for fundamental and applied research, for process development and design, for production, and even for management, technical services and sales. Private consulting work and careers in teaching usually demand a period of advanced study well beyond the normal four-year undergraduate program.

At present, major emphasis in the department is concerned with basic studies of unit operations such as fluid flow, heat transfer at high and low temperatures, distillation, solvent extraction, etc., with thermodynamics, reaction kinetics, phase equilibria, plastics technology, process measurement and control, and many other aspects of chemical technology. A new laboratory devoted exclusively to the study of thermal properties of materials provides unique facilities for graduate work in this important field. Strong supporting programs of work are also available in mathematics, statistics, physics, chemistry, nuclear engineering, metallurgy, the life sciences, textiles, and other fields of engineering.

The Department of Chemical Engineering occupies the entire four-story east wing of the new Riddick Engineering Laboratories building. Modern, well-equipped laboratories are provided with all necessary services for both teaching and research. A wide variety of special facilities such as X-ray equipment, spectrophotometers, electron microscope, electro-mechanical testing machine, electronic controllers and recorders, etc., are available for graduate research.

Assistantships

In cooperation with the Department of Engineering Research, members of the chemical engineering staff are engaged in conducting a number of important research projects which are supported by industry, and by State and governmental agencies. Graduate students assisting on these projects not only acquire financial assistance but gain valuable research experience on problems of current interest.

In addition to research assistantships, the department also offers each year a limited number of graduate assistantships for part-time work in the department. These may be for teaching, laboratory preparation, etc., or for research, as the need arise. Appointments are for one academic year of nine months for half-time work and at the present carry a stipend of \$2,400. They are renewable upon evidence of satisfactory performance.

Courses for Advanced Undergraduates

- CHE 411. Unit Operations I** 4-0
 Required of Juniors in Chemical Engineering.
 Prerequisites: MA 202, PY 202.
 Principles of fluid flow, heat transfer, evaporation, etc., with emphasis on design calculations.
- CHE 412. Unit Operations II** 4-0
 Required of Seniors in Chemical Engineering.
 Prerequisite: CHE 411.
 A continuation of CHE 411 with emphasis on the diffusional operations such as absorption, distillation, extraction, drying, etc.
- CHE 415. Chemical Engineering Thermodynamics** 4-0
 Required of Juniors in Chemical Engineering.
 Prerequisite: CHE 311.
 A study of the laws of thermodynamics and their application to chemical engineering problems. Emphasis on the theory, data and approximation methods as applied to physical and chemical systems.
- CHE 431, 432. Unit Operations Laboratory I and II** 3-3
 Required of Seniors in Chemical Engineering.
 Prerequisite: CHE 411.
 Laboratory work on typical apparatus involving the unit operations. Experiments are designed to augment the theory and data of the lecture courses and to develop proficiency in the writing of technical reports.
- CHE 453. Chemical Processing of Radioactive Materials** 3 or 3
 Consideration of the unique procedures required for the bulk manipulation of radioactive chemicals. Particular attention is given to remote operational procedures of precipitation, centrifugation, conveying, solvent extraction and ion exchange. Design of apparatus involving low maintenance and ease of replacement and cleaning by safe methods is considered. Other topics include decontamination procedures in disposal of wastes.
- CHE 460. Seminar** 1 or 1
 One semester required of Seniors in Chemical Engineering.
 Literature survey of selected topics in chemical engineering. Emphasis on written and oral presentation.
- CHE 470. Chemical Engineering Projects.** 2 or 2
 Introduction to research through experimental, theoretical and literature studies of chemical engineering problems. Oral and written presentation of reports.

Courses for Graduates and Advanced Undergraduates

- CHE 525. Process Measurement and Control** 3 or 3
 Prerequisite: CHE 411.
 Theory and application of methods for measuring, transmitting, recording and controlling such process variables as temperature, pressure, flow rate, liquid level, concentration, humidity, etc. Commercial instruments are utilized for study of a wide variety of industrial control problems. Recorder-controllers are available for simulating industrial control problems of varying difficulty.
- CHE 527. Chemical Process Engineering** 0-3
 Prerequisite: CHE 412.
 A study of selected chemical processes with emphasis on the engineering, chemical and economic factors involved. Mr. Pike.
- CHE 540. Electrochemical Engineering** 3 or 3
 Prerequisite: Physical Chemistry.
 The application of electrochemical principles to such topics as electrolysis, electroanalysis, electroplating, metal refining, etc. Mr. Schoenborn.
- CHE 541. Cellulose Industries** 3 or 3
 Prerequisite: Organic Chemistry.
 Methods of manufacture and application of cellulose chemical conversion

products. Emphasis placed on recent developments in the field of synthetic fibers, films, lacquers, and other cellulose compounds. Mr. Seely.

CHE 542. Technology of Pulp and Paper 3 or 3
Prerequisite: Organic Chemistry.

Fundamentals of pulp and paper manufacture with emphasis on recent advances in the field. One laboratory period per week is devoted to topics such as digestion and treatment of pulp, hardsheet preparation and testing, fiber analysis, and chemical and physical tests. Mr. Seely.

CHE 543. Technology of Plastics 3 or 3
Prerequisite: Organic Chemistry.

The properties, methods of manufacture, and applications of synthetic resins. Recent developments in the field are stressed. Mr. Seely.

CHE 545. Petroleum Refinery Engineering 3 or 3
Prerequisite: CHE 412.

An introduction to the petroleum industry including (1) nature of petroleum and its fractions, octane numbers, viscosity relationships, etc., (2) operations of thermal and catalytic cracking, stabilization, alkylation, isomerization, crude fractionation, etc., (3) problem work covering high pressure phase relationships, and related material. Mr. Pike.

CHE 546. Chemical Reaction Rates 3 or 3
Prerequisite: CHE 415.

A basis study of the rates of homogeneous reactions, heterogeneous reactions, and catalysis.

CHE 551. Thermal Problems in Nuclear Engineering 3 or 3
Prerequisites: ME 302 or 303; or CHE 411; or equivalent.

The design and operation of nuclear reactors and the utilization of the power from them involves major problems in nearly every phase of heat transfer, and many important problems in fluid flow. Possible solutions to these problems are severely affected by the influences of radiation on heat transfer media, hazards of handling radioactive substances, etc. The course considers the thermal problems of nuclear reactor design and the principles of fluid flow and heat transfer necessary to their solutions.

The course is intended for engineers and science students with backgrounds in physics and mathematics and elementary thermodynamics. Mr. Beatty

CHE 553. Separation Processes in Nuclear Engineering 3 or 3
Prerequisite: CHE 412 or equivalent.

A study of the principles and techniques of separation and purification of chemical components, based upon mass transfer by diffusion. Specific techniques covered are distillation, extraction, adsorption and ion exchange, particularly in regard to continuous, counter-current operations. Special topics include a survey of fuel processing, technology of uranium processing, complexing action of solvents, and halide distillation.

The course is primarily intended for engineers and science students with backgrounds in mathematics, physics and elementary chemistry but who have had no previous course in separation processes. Mr. Pike

CHE 570. Chemical Engineering Projects

1 to 3 credits

Prerequisite or concurrent: CHE 412.

A laboratory study of some phase of chemical engineering or allied field.
Graduate Staff

Courses for Graduates Only

CHE 610. Heat Transfer I

3 or 3

Prerequisite: CHE 411.

An advanced course dealing primarily with heat transfer between liquids and solids, optimum operating conditions and design of equipment, conduction, heating and cooling of solids, radiant heat transmission.

Mr. Beatty.

CHE 611. Heat Transfer II

2 or 2

Prerequisite: CHE 610.

An intensive study of recent advances in heat transfer and allied fields.

Mr. Beatty.

CHE 612. Diffusional Operations

3 or 3

Prerequisite: CHE 412.

An advanced treatment of mass transfer particularly as applied to absorption, extraction, drying, humidification and dehumidification.

Mr. Schoenborn.

CHE 613. Distillation

3 or 3

Prerequisite: CHE 412.

Vapor-liquid equilibria of non-ideal solutions, continuous distillation of binary and multicomponent systems, batch distillation, azeotropic and extractive distillation.

Mr. Schoenborn.

CHE 614. Drying of Solids

2 or 2

Prerequisite: CHE 412.

An advanced course on the mechanism of drying operations with application to design of equipment, such as cabinet, tunnel, rotary, drum and spray driers.

Mr. Pike.

CHE 615. Thermodynamics I

3 or 3

Prerequisite: CHE 415.

Advanced topics in chemical engineering thermodynamics including equilibria of physical and chemical systems, high pressure systems, generalized properties of hydrocarbon, etc.

Mr. Beatty.

CHE 616. Thermodynamics II

2 or 2

Prerequisite: CHE 615.

An intensive study of recent advances in thermodynamics.

Mr. Beatty.

CHE 617. Catalysis of Industrial Reaction

3 or 3

Prerequisite: CHE 546.

A study of the mechanism of catalysis with emphasis on practical application to operation and design of industrial processes. Graduate Staff

CHE 631, 632. Chemical Process Design

3-3

Prerequisite: CHE 412.

Design and selection of process equipment, through solution of comprehensive problems involving unit operations, kinetics, thermodynamics, strength of materials and chemistry.

Graduate Staff.

CHE 641, 642. Advanced Chemical Engineering Laboratory

2-2

Prerequisite: CHE 412.

Advanced laboratory work in a selected field with emphasis on theory, techniques and performance of equipment.

Graduate Staff.

CHE 650. Advanced Topics in Chemical Engineering

**1 to 3 credits
per semester**

A study of recent development in chemical engineering theory and practice, such as ion exchange, crystallization, mixing, molecular distillation, hydrogenation, fluorination, etc. The topic will vary from term to term.

Graduate Staff.

CHE 660. Chemical Engineering Seminar

1 credit per semester

Literature investigations and reports of special topics in chemical engineering and allied fields.

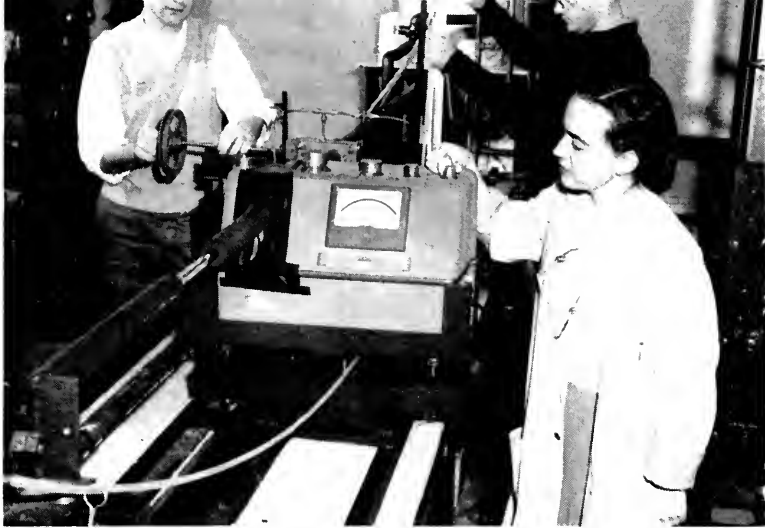
Graduate Staff.

CHE 680. Chemical Engineering Research

Credits by arrangement

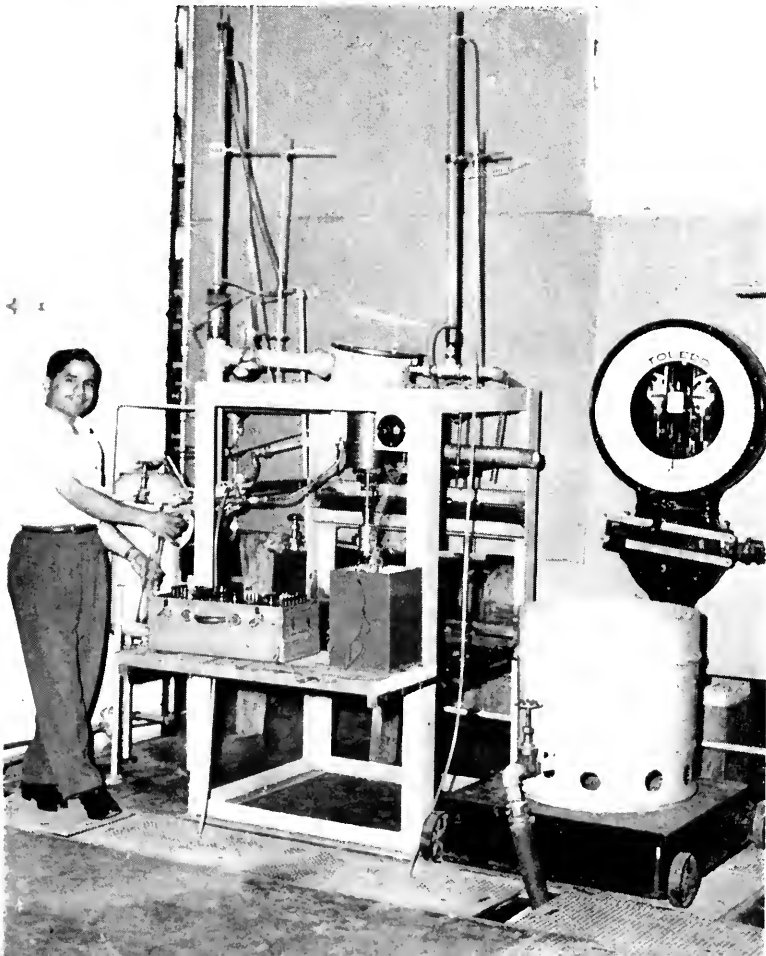
Independent investigation of an advanced chemical engineering problem. A report of such an investigation is required as a graduate thesis.

Graduate Staff.



Chemical Engineering graduate students assist technical director in research project investigating the flow of fluids.

Chemical Engineering student works with special equipment to study condensation on a rotating surface.





Chromatographic apparatus for isolation of insecticide residues from biological material.

Recording spectrophotometer for study of chemical systems by light absorption.



Warburg apparatus for study of intermediary metabolism.

DEPARTMENT OF CHEMISTRY

Graduate Faculty

Professors:Head, THOMAS GLENN BOWERY, RICHARD HENRY LOEPPERT, WALTER JOHN PETERSON, WILLIS ALTON REID, COWIN COOK ROBINSON, GEORGE HOWARD SATTERFIELD, PAUL PORTER SUTTON, JOSEPH ARTHUR WEYBREW.

Associate Professors: ALONZO FREEMON COOTS, ROBERT LAWRENCE STEPHENS, SAMUEL B. TOVE, RAYMOND CYRUS WHITE.

Assistant Professor: GEORGE GILBERT LONG.

The Department of Agricultural and Biological Chemistry offers the Degree of Master of Science in Agricultural and Biological Chemistry. Before the master's degree is awarded, a student must have met the requirements set forth by the Committee on Professional Training of the American Chemical Society for the baccalaureate degree, either at the institution in which he received his undergraduate training or at this institution. (Briefly the minimum course requirements in Chemistry for the bachelor's degree consist of four basic year courses in general chemistry, analytical chemistry, physical chemistry, and organic chemistry, together with at least one advanced course. Mathematics, comprising the equivalent of two years of college work, which must include one year of differential and integral calculus, is also required).

Instruction in Agricultural and Biological Chemistry trains students in this area of chemistry, strongly supported with fundamental training in the major divisions of chemistry and their applications. Educational, commercial, and research positions are open to men and women trained in the chemistry of plants, animals, soils, fertilizers, insecticides, foods and feeds, vitamins and nutrition, and clinical and biophysical chemistry. In the past the majority of graduates with the degree of Master of Science have continued their education toward the degree of Doctor of Philosophy with a major in one of the branches of chemistry.

The Department of Agricultural and Biological Chemistry is adequately equipped with standard instruments and apparatus available for both teaching and research. A sizeable assortment of specialized equipment is also available such as: refractometers, incubators, forced air ovens, several spectrophotometers and photoelectric colorimeters, fluorophotometers, polarographs, etc. The spectrographic laboratory is one of the most complete to be found anywhere and is currently providing analyses for 10 elements on each of 25 plant samples per week.

An up-to-date shop equipped with standard power tools (drill press, lathes, band saws, etc.) is available to research workers for construction of special apparatus. Complete glass-blowing facilities are also available.

Complete sets of reference works of more than one hundred chemical (including biochemical and nutritional) journals in English, German and French are accessible for student use in the D. H. Hill Library. Current numbers of the most widely used chemical journals (including all of those published by the American Chemical Society) are available in the Chemistry Library.

Research:

Some of the areas of specialization for research studies available include (1) the isolation, chemical nature, and nutritional significance of certain growth factors required by bacteria and yeasts; (2) soils and weather factors influencing the composition of plants; (3) vitamin and/or mineral studies of plants grown in the South, influence of variety, fertilization, etc.; (4) vitamin methodology; (5) nutritional requirements of various farm animals (in cooperation with the Nutrition Section, Animal Industry Department); (6) mechanisms involved in plant physiological processes; (7) techniques of spectrographic analysis and their applications in research with plants, soils, and animals; (8) preparation and characterization of fat acid esters and derived products; (9) others.

Courses for Advanced Undergraduates

- CH 401. Special Topics in Inorganic Chemistry 3-0
Prerequisite: CH 215.
Structure of matter, periodic system, electronic structure and chemical bonding, acids, bases, salts, preparation of elements, halogen compounds, hydrides and carbonyls.
Messrs. White, Long.
- CH 421-422. Organic Chemistry 5-5
Prerequisite: CH 212.
Aliphatic and aromatic compounds, methods of preparation and purification, and identification of compounds; emphasis on structure and mechanism of organic reactions.
Mr. Reid.
- CH 425-426. Organic Chemistry 3-3
Prerequisite: CH 215.
Structure, preparation, properties, and reactions of aliphatic and aromatic substances.
Mr. Loeppert.
- CH 439. Organic Preparations 0-3
Prerequisites: Three years of Chemistry including Organic Chemistry.
Experiments selected to acquaint the student with advanced methods and techniques in the preparation of organic substances.
Mr. Loeppert.
- CH 451. Introductory Biochemistry 3-0 or 0-3
Prerequisite: CH 203.
The fundamental biochemistry of living matter.
Mr. Satterfield.

Courses for Graduates and Advanced Undergraduates

- CH 512. Chemistry of High Polymers (See TC 512.)
- CH 527. Advanced Survey of Organic Chemistry 0-3
Prerequisites: Three years of Chemistry including Organic Chemistry.
Underlying principles, interpretation of mechanisms, limitations in the use of organic reactions.
Mr. Reid.
- CH 528. Qualitative Organic Analysis 3-0
Prerequisites: Three years Chemistry including Organic Chemistry.
A study of class reactions, functional groups, separation, identification and preparation of derivatives.
Mr. Reid.
- CH 529. Quantitative Organic Analysis 0-3
Prerequisites: Three years of Chemistry including Organic Chemistry.
Quantitative determination of carbon, hydrogen, nitrogen, the halogens, sulfur and various functional groups in organic materials, with emphasis on semimicro methods.
Mr. Loeppert.
- CH 531-532. Physical Chemistry 3-3
Prerequisites: CH 215, PY 202, MA 202.

An intensive study of the states of matter, solutions, colloids, homogeneous and heterogeneous equilibrium, reaction kinetics, electrolysis, conductance, oxidation reactions, ionic equilibrium. Mr. Sutton.

CH 531L-523L. Physical Chemistry Laboratory 1-1

Prerequisites: CH 215, PY 202, MA 202.

Laboratory course to accompany lecture work in physical chemistry.

Mr. Sutton.

CH 533. Physical Chemistry 3-0

Prerequisite: CH 532.

An intensive study of the structure of atoms and molecules, an introduction to chemical statistics and selected subjects in chemical thermodynamics. Mr. Sutton.

CH 537. Instrumental Methods of Analysis 0-4

Prerequisites: Three years of Chemistry including CH 532.

Physical methods of chemical analysis, the instruments employed and the theoretical basis for their operation. Mr. Long.

CH 542. Colloid Chemistry 0-3

Prerequisite: CH 426.

Adsorption, preparation, properties, constitution, stability, and application of sols, gels, emulsions, foams, and aerosols; dialysis, Donnan membrane equilibrium. Mr. White.

CH 543. Radioisotope Principles 3-0

Prerequisites: CH 212 or CH 215, PY 212 or PY 202, MA 212 or MA 202.

A presentation of the basic knowledge of radioactivity, nuclear reactions, ionizing radiations, and radiochemistry essential to competence in the use of radioisotopes. Mr. Coots.

CH 543L. Radioisotope Techniques 1-0

Prerequisite: CH 543 (prior to or concurrently, or equivalent).

A laboratory course in the physical and chemical techniques essential to competence in the use of radioisotopes. Mr. Coots.

CH 551. General Biological Chemistry 5-0

Prerequisites: CH 422, or equivalent of three years of Chemistry.

The chemical constitution of living matter. Biochemical processes as well as compounds are studied; lectures, laboratory. Mr. Peterson.

CH 552. Physiological Chemistry 0-3

Prerequisite: CH 551.

Digestion, absorption, metabolism, secretions, and excretions. Laboratory will include analysis of blood and urine. Mr. Satterfield.

CH 555. Plant Chemistry 0-3

Prerequisite: CH 551.

Composition of plants, properties, nature, and classification of plant constituents, changes occurring during growth, ripening, and storage of plants or plant products. Mr. Stephens.

- CH 561. Chemistry of Carbohydrates and Lipides** 3-0
 Prerequisites: CH 422 or equivalent of three years of chemistry.
 Classification, composition, distribution, biosynthesis, and metabolism of lipides and carbohydrates; analysis, synthesis, deterioration, physical properties, and chemical reactions are also considered. Mr. Robinson.
- CH 562. Chemistry of Proteins and Nucleic Acids** 0-3
 Prerequisites: CH 422, 551, or equivalent of three years of Chemistry.
 Composition, distributions, structure, properties, and metabolism of amino acids, proteins and nucleic acids. Mr. Peterson.
- CH 572. Chemistry of the Vitamins** 0-3
 Prerequisites: CH 422, or equivalent of three years of Chemistry.
 History, nomenclature, properties, distribution, effects of deficiencies, vitamin values. Mr. Satterfield.

Courses for Graduates Only

- CH 601. Advanced Organic Chemistry** 3-0
 Prerequisite: CH 527.
 Alicyclic and heterocyclic compounds, macromolecules, standard type reactions. Messrs. Reid, Loeppert, Robinson.
- CH 602. Advanced Organic Chemistry** 0-3
 Prerequisites: CH 422, 532.
 Theoretical and physical aspects of Organic Chemistry; relations between chemical constitution and properties. Mr. Loeppert.
- CH 621 (AI 621). Enzymes and Intermediary Metabolism** 4-0
 Prerequisites: CH 551 and permission of Instructor.
 A study of the properties of enzymes and enzyme action, intermediary metabolism of carbohydrates, amino acids, fatty acids, vitamins, purines and porphrins, metabolic energy relationships. Mr. Tove.
- CH 622. Principles of Biological Assays**
 (See AI 622).
- CH 631. Chemical Research** Credits by arrangement.
 Prerequisites: 40 semester credits in Chemistry. Open to all graduates.
 Special problems that will furnish material for a thesis. A maximum of 6 semester credits is allowed.
 Graduate Staff.
- CH 641. Seminar** Credits by arrangement.
 Prerequisite: Graduate standing in Chemistry.
 Required of graduate students specializing in Chemistry.
 Scientific articles, progress reports in research, and special problems of interest to chemists are reviewed and discussed.
 A maximum of two semester credits is allowed.
 Graduate Staff.
- CH 651. Special Topics in Chemistry** Max. 3
 Prerequisite: Graduate standing in Chemistry.
 Critical study of some special problems in one of the branches of Chem-

istry, involving original investigation together with a survey of pertinent literature.

Graduate Staff.

CH 671, 672. Advanced Physical Chemistry

3-3

Prerequisite: CH 532.

The work of 671 will involve a thorough review of the fundamental principles of physical chemistry with extension and application of these to the study of the solid state. In 672 there will be laid down the elements of statistical mechanics and kinetic theory, in terms of which certain topics from 671 will be more exhaustively developed. Solution of problems will play an important role in 671.

Mr. Sutton.

DEPARTMENT OF CIVIL ENGINEERING

Graduate Faculty

Professors: RALPH EIGIL FADUM, Head, CHARLES RAYMOND BRAMER, CHARLES RUSSELL MCCULLOUGH, CARROLL LAMB MANN, JR., CHARLES SMALLWOOD, JR., MEHMET ENSAR UYANIK.

Associate Professors: ROBERT ALDEN DOUGLAS, MICHAEL V. SMIRNOFF.

Assistant Professor: PAUL D. CRIBBINS, JOHN WILLIAM HORN.

The Department of Civil Engineering offers programs of graduate study leading to the degree of Master of Science and Doctor of Philosophy. Graduate course work is available in the specialty fields of sanitary engineering, soil mechanics and foundation engineering, structural engineering, and transportation engineering. Whereas the Master of Science program would normally include course work in only one of these specialty fields, a program of study leading to the Doctor of Philosophy degree would encompass course work in a related combination of these fields.

Laboratory facilities for sanitary engineering research work include an hydraulics laboratory, a chemical laboratory and a biological laboratory.

For work in soil mechanics and foundation engineering, a fully-equipped laboratory with modern soil-testing equipment is available.

Facilities for structural engineering research include a well-equipped physical testing laboratory and in addition an air-conditioned structural models laboratory.

Transportation engineering facilities include a bituminous laboratory, an airphoto interpretation laboratory, a photogrammetry laboratory, and a traffic engineering laboratory provided with traffic control devices.

In addition to these facilities, equipment for research is made available by the Department of Engineering Research.

Some unique opportunities for research are offered the graduate student in civil engineering by reason of the location of North Carolina State College in the State's capital city. There are a number of cooperative research endeavors with municipal and state governmental agencies that enable the student to gain valuable experience through an application of his knowledge and skill to practical engineering problems.

Courses for Advanced Undergraduates

- CE 425. Structural Analysis II** 3-0
 Prerequisites: CE 324 and EM 321.
 Required of seniors in Civil Engineering.
 Deflection of beams and trusses; indeterminate stress analysis by moment area, slope deflection and moment distribution.
- CE 427. Structural Design I** 4-0
 Prerequisite: EM 321.
 Required of seniors in Civil Engineering and Civil Engineering Construction Option.
 Analysis and design of reinforced concrete building elements; design of tension, compression and simple flexural members of steel and of timber.
- CE 428. Structural Design II** 0-3
 Prerequisite: CE 427.
 Required of seniors in Civil Engineering.
 Design specifications; connection details; independent and complete design of engineering structures.
- CE 429. Elements of Structural Design II** 0-3
 Prerequisite: CE 427.
 Required of seniors in Civil Engineering Construction Option.
 Design of tension, compression and flexural elements of steel and timber; solution of problems in erection, forms, shoring and falsework.
- CE 442. Soil Mechanics** 3-0
 Prerequisite: CE 305.
 Required of seniors in Civil Engineering.
 Fundamental stress relations, Mohr's rupture hypothesis, shearing strength, earth pressure theories, bearing capacity, stability of slopes, hydrostatics, and hydrodynamics of ground water.
- CE 443. Foundations** 0-3
 Prerequisite: CE 427.
 Required of seniors in Civil Engineering Construction Option.
 Identification and classification of soils; geological aspects of foundation engineering; methods of investigating subsoil conditions; control of water; types of foundations and conditions favoring their use; legal aspects of foundation engineering.
- CE 461. Project Planning and Control I** 3-0
 Prerequisite: CE 362.
 Required of seniors in Civil Engineering Construction Option.
 Analysis of construction plant layout requirements and performance characteristics of equipment.
- CE 462. Project Planning and Control II** 0-3
 Prerequisite: CE 461.
 Required of seniors in Civil Engineering Construction Option.
 Scheduling, analysis and control of construction projects.
- CE 464. Legal Aspects of Contracting** 0-3
 Prerequisite: Senior standing.
 Required of seniors in Civil Engineering Construction Option; elective.
 Legal aspects of construction contract documents and specifications; owner-engineer-contractor relationships and responsibilities; bids and contract performance; labor laws.
- CE 481. Hydrology and Drainage** 2-0
 Prerequisite: CE 382.
 Required of seniors in Civil Engineering.
 Occurrence and distribution of rainfall; runoff, surface and ground waters; design of drainage and control structures.
- CE 482. Water and Sewage Works** 0-3
 Prerequisite: Senior standing.
 Required of seniors in Civil Engineering.
 Water supply analysis and design, including population estimates, consumption, source selection, aqueducts, distribution systems and pumping stations; elements of water treatment; collection and disposal of sewage; elements of sewage treatment.
- CE 485. Elements of Hydraulics and Hydrology** 3-0
 Prerequisite: EM 312.
 Required of seniors in Civil Engineering Construction Option.
 Elements of fluid mechanics, hydraulics and hydrology, with application to problems in construction engineering.
- CE 492, 493. Professional Practice I, II** 1-1
 Prerequisite: Senior standing.
 Required of seniors in Civil Engineering and Civil Engineering Construction Option.
 Professional engineering societies and their functions; professional standards; topics of current interest to the civil engineer.

Courses for Graduates and Advanced Undergraduates

- CE 507. Airphoto Analysis I** 3-0
 Prerequisite: Junior standing.
 Engineering evaluation of aerial photographs, including analysis of soils and surface drainage characteristics. Mr. McCullough.
- CE 508. Airphoto Analysis II** 0-3
 Prerequisite: CE 507.
 Engineering evaluation of aerial photographs for highway and airport projects. Mr. McCullough.
- CE 509. Photogrammetry** 0-3
 Prerequisites: CE 201 or CE 217.
 Elements of photogrammetry as applied to surveying and mapping. Aerial and terrestrial photogrammetry. Flight planning and ground controls. Stereoscopy and stereoscopic plotting instruments. Measurements on photographs. Mr. Smirnoff.
- CE 510. Advanced Surveying** 3 or 3
 Prerequisite: CE 202.
 State coordinate systems and map projections. Elements of geodetic and astronomical surveying. Adjustment of observations by the method of least squares. Mr. Smirnoff.
- CE 514. Municipal Engineering Projects.** 3-0
 Prerequisite: Senior Standing in Civil Engineering.
 Special problems relating to public works, public utilities, urban planning and city engineering. Messrs. Horn, Smallwood.
- CE 515. Transportation Operations.** 3-0
 Prerequisite: CE 306.
 The analysis of traffic and transportation engineering operations. Messrs. Cribbins, Horn.
- CE 516. Transportation Design.** 3 or 3
 Prerequisite: CE 306.
 The geometric elements of traffic and transportation engineering design. Messrs. Cribbins, Horn.
- CE 521, 522. Advanced Structural Design I, II** 3-3
 Prerequisite: CE 425.
 Complete structural designs of a variety of projects; principles of limit and prestress design. Messrs. Uyanik and Bramer.
- CE 524. Analysis and Design of Masonry Structures** 0-3
 Prerequisite: CE 425.
 Analysis and design of arches, culverts, dams, foundations and retaining walls. Mr. Bramer.
- CE 531. Experimental Stress Analysis.** 3-0
 Prerequisite: CE 425.
 Principles and methods of experimental analysis; dimensional analysis; applications to full-scale structures. Mr. Bramer.

- CE 532. Structural Laboratory** 0-3
 Prerequisite: CE 531.
 Test procedures and limitations and interpretation of experimental results. Mr. Bramer.
- CE 544. Foundation Engineering** 3 or 3
 Prerequisite: CE 442.
 Subsoil investigations; excavations; design of sheeting and bracing systems; control of water; footing; grillage and pile foundations; caisson and cofferdam methods of construction; legal aspects of foundation engineering. Mr. Fadum.
- CE 547. Fundamentals of Soil Mechanics.** 3 or 3
 Prerequisite: EM 321.
 Physical and mechanical properties of soils governing their use for engineering purposes; stress relations and applications to a variety of fundamental problems. Mr. Fadum.
- CE 548. Soil Testing for Engineering Purposes** 3 to 6
 Prerequisite: CE 442 or CE 547.
 Qualitative and quantitative soil testing procedures for engineering purposes. Messrs. Fadum and McCullough.
- CE 570. Sanitary Microbiology** 3 or 3
 Prerequisite: BO 412.
 Dynamics of disinfection and bacteriostasis; microbiology of water and sewage and of sewage treatment processes. Mr. Smallwood
- CE 571. Theory of Water and Sewage Treatment** 3-0
 Prerequisite: Senior standing.
 Study of the physical and chemical principles underlying water and sewage treatment processes; diffusion of gases, solubility, equilibrium and ionization, anaerobic and aerobic stabilization processes, sludge conditioning and disposal. Mr. Smallwood.
- CE 572. Unit Operations and Processes in Sanitary Engineering** 0-3
 Prerequisite: CE 571.
 Processes and operations in sanitary engineering; sedimentation, aeration, filtration, adsorption, coagulation, softening, sludge digestion, aerobic treatment of sewage. Mr. Smallwood.
- CE 573. Analysis of Water and Sewage** 3-0
 Corequisite: CE 571.
 Chemical and physical analysis of water and sewage and interpretation of results. Mr. Smallwood.
- CE 574. Radioactive Waste Disposal** 3 or 3
 Prerequisite: PY 410.
 Unit operations and processes employed in treatment and disposal of radioactive wastes. Mr. Smallwood.

- CE 591, 592. Civil Engineering Seminar 1-1
Discussions and reports of subjects in civil engineering and allied fields.
Graduate Staff.
- CE 598. Civil Engineering Projects Credits by arrangement
Special projects in some phase of civil engineering. Graduate Staff.

Courses for Graduates Only

- CE 601. Transportation Planning 0-3
Prerequisite: CE 515.
The planning, administration, economics and financing of various transportation engineering facilities. Messrs. Cribbins, Horn.
- CE 602. Advanced Transportation Design 0-3
Prerequisite: CE 516
Design of major transportation engineering projects.
Messrs. Cribbins, Horn.
- CE 603. Airport Planning and Design 3-0
Corequisites: CE 515 and CE 516.
The analysis, planning and design of air transportation facilities.
Messrs. Cribbins, Horn.
- CE 604. Urban Transportation Planning 0-3
Prerequisite: CE 515.
Thoroughfare planning as related to land usage and urban master-planning.
Messrs. Cribbins, Horn.
- CE 621, 622. Advanced Structural Analysis I, II 3-3
Prerequisite: CE 425.
Analysis of rigid frames and continuous structures; treatment of redundant members and secondary stresses. Mr. Bramer.
- CE 624. Theory and Design of Arches, Thin Shells and Domes 0-3
Prerequisite: CE 621.
Corequisite: EM 602.
Analysis and design of hinged and rigid arches of both frame and rib construction; and of thin shells and domes.
Messrs. Bramer and Uyanik.
- CE 626. Structural Connections 0-3
Prerequisite: CE 621.
Analysis of stresses in simple, rigid and semi-rigid connections; critical review of specifications. Messrs. Bramer and Uyanik.
- CE 641, 642. Advanced Soil Mechanics 3-3
Prerequisite: CE 442.
Corequisite: CE 547.
Theories of soil mechanics; failure conditions; mechanical interaction between solids and water, and problems in elasticity pertaining to earth-work engineering. Mr. Fadum.

- CE 643. Hydraulics of Ground Water** 3 or 3
 Prerequisite: CE 442 or CE 547.
 Principles of ground water hydraulics; theory of flow through idealized porous media; the flow net solution; seepage and well problems.
 Mr. Fadum.
- CE 671. Advanced Water Supply and Sewerage** 4-0
 Prerequisite: CE 482.
 Problems relating to the design of water supply and sewerage works.
 Mr. Smallwood.
- CE 672. Advanced Water and Sewage Treatment** 0-4
 Prerequisite: CE 482.
 Problems relating to the treatment of water and sewage.
 Mr. Smallwood.
- CE 673. Industrial Water Supply and Waste Disposal** 3 or 3
 Corequisite: CE 571.
 Water requirements of industry and the disposal of industrial wastes.
 Mr. Smallwood.
- CE 674. Stream Sanitation** 3 or 3
 Corequisite: CE 571.
 Biological, chemical and hydrological factors that affect stream sanitation and stream use.
 Mr. Smallwood.
- CE 698. Civil Engineering Research** Credits by arrangement
 Independent investigation of an advanced civil engineering problem; a report of such an investigation is required as a graduate thesis.
 Graduate Staff.

DAIRY MANUFACTURING

Dairy Manufacturing is organized as a unit of the Department of Animal Industry. For a list of the faculty and a description of the resources of the Department, consult the section of the catalog under Animal Industry.

Courses for Advanced Undergraduates

- DM 400. Dairy Plant Experience** Maximum 6
 Prerequisite: Approval of Adviser.
 Practice in processing dairy products, including market milk, ice cream, cheese, butter and concentrated milks; application of laboratory control; and practice in dairy equipment maintenance. Required of all Dairy Manufacturing majors, unless proof of equivalent experience can be shown.
 Staff.
- DM 401. Market Milk and Related Products** 0-3
 Prerequisite: Approval of Instructor.
 Principles and information on the production, processing, distribution, and public health control of fluid milk and related products.
 Mr. Roberts.
- DM 402. Cheese** 0-3
 Prerequisite: Approval of Instructor.
 Principles and practice in the manufacture and curing of various types of cheese; importance and propagation of cheese starters.
 Mr. Warren.
- DM 403. Ice Cream and Related Frozen Dairy Foods** 3-0
 Prerequisite: Approval of Instructor.
 Choice, preparation, and processing of ingredients and freezing of ice cream and other frozen desserts.
 Mr. Warren.

- DM 404. Butter and Dairy By-Products** 0-3
 Prerequisite: Approval of Instructor.
 A study of the fundamentals of buttermaking, and the principles of manufacturing concentrated and dried milks. Mr. Warren.
- DM 405. Dairy Mechanics** 1-0
 Prerequisite: Approval of Instructor.
 Laboratory practice in the operation and maintenance of dairy plant equipment and refrigeration systems; malfunctions of electrical systems; installation of sanitary milk lines, and water lines. Staff.
- DM 406. Judging Dairy Products** 0-1
 Prerequisite: Approval of Instructor.
 Milk and dairy products judging according to official standards and commercial grades. Mr. Warren.
- DM 407, BO 407. Dairy Bacteriology I** 4-0
 Prerequisite: General Bacteriology BO 312.
 Applications of the principles of bacteriology to the production of quality milk and maintenance of quality in processing milk and milk products; various desirable and undesirable activities of bacteria in milk; methods of enumerating bacteria; detecting certain groups of bacteria of particular importance, and the relationship of bacteria in milk to public health. Mr. Speck.

Courses for Advanced Undergraduates and Graduates

- DM 501. Advanced Dairy Technology** 3-0
 Prerequisite: DM 401.
 The functions and operations of a dairy control laboratory; a comprehensive study of methods of analyses of dairy products and related non-dairy products; the application and interpretations of methods for quality and composition control of dairy products. Mr. Warren.
- DM 504. Dairy Plant Management** 0-4
 Prerequisite: DM 401.
 Business and factory management practices as used in the dairy plant. Mr. Roberts.
- DM 506. (BO 506) Dairy Bacteriology II** 0-3
 Prerequisite: DM 407 (BO 407) or equivalent.
 A detailed study of bacteria particularly involved in the dairy industry regarding their physiology, morphology, and cultural characteristics with application to practical dairy farm and plant problems. Mr. Speck.
- DM 508. Dairy Chemistry** 3-0
 Prerequisite: CH 103 or 203, DM 401.
 A qualitative study of the physical, colloidal and chemical properties of milk and its constituents. Mr. Aurand.

Courses for Graduates Only

- DM 601. Seminar in Dairy Manufacturing** 1 Credit Per Term
 Prerequisite: Graduate Standing in Dairy Manufacturing.
 Scientific articles, progress reports in research and special problems of interest are reviewed and discussed.
 A maximum of two credits is allowed toward the Master's Degree, but any number toward the Doctorate. Staff.
- DM 602. Advanced Dairy Chemistry** 4 or 4
 Prerequisite: DM 508.

A quantitative study of the physical, colloidal, and chemical properties of milk and its constituents. Mr. Aurand.

DM 603. (BO 603) Advanced Dairy Bacteriology 4 or 4
Prerequisite: DM 506. (BO 506).

A study of nutritional and physiological relationships among the lactic acid bacteria. Mr. Speck.

DM 604. Topical Problems in Dairy Manufacturing 1 to 3 Credits
Per Term

Prerequisite: Graduate Standing in Dairy Manufacturing.

Special problems in various phases of Dairy Manufacturing. Problems may be selected or assigned. A maximum of six credits is allowed. Staff.

DM 605. Research in Dairy Manufacturing Credit by arrangement
Prerequisite: Graduate Standing in Dairy Manufacturing.

A maximum of six credits is allowed toward the Master's Degree; no limitation on credits in Doctorate Programs. Graduate Staff.

DIESEL ENGINEERING

See Department of Mechanical Engineering

DEPARTMENT OF ECONOMICS

Graduate Faculty

Professors: ERNST W. SWANSON, Head, C. ADDISON HICKMAN.

Associate Professors: ROBERT L. BUNTING, CLEON HARRELL, BERNARD M. OLSEN.

Assistant Professors: GERALD GARB, THOMAS H. PARK, CHING S. SHEN.

No graduate degrees are currently offered in Economics at North Carolina State College. The courses listed below are eligible for graduate credit when they form a part of an approved graduate program in other departments, and Economics may serve as a minor field.

Courses for Advanced Undergraduates

EC 401, 402. Principles of Accounting 3-3
Fundamental principles of accounting theory and practice; the analysis and recording of business transactions; explanation and interpretation of the structure, form, and use of financial statements.

EC 407. Business Law I 3 or 3
Prerequisite: EC 201 or EC 205.
A course dealing with elementary legal concepts, contracts, agency, negotiable instruments, sales of personal property, chattel mortgages, partnerships, corporations suretyship and bailments, insurance.

EC 408. Business Law II 3 or 3
Prerequisite: EC 407.
Deals with real property, mortgages on urban and farm lands, landlord and tenant, requirements for valid deed, insurance law, wills, suretyship and conditional sales.

EC 409. Introduction to Production Costs 0-3
Prerequisite: EC 312.
An introduction to accounting problems peculiar to manufacturing, fabrication, and construction-type enterprises. Cost determination and allocation of costs for materials, labor, and overhead to the various units of product. Estimating and cost control in the production and manufacturing process. Special emphasis to be placed on analysis and interpretation of cost data.

- EC 410. Industry Studies** 3 or 3
 Prerequisite: EC 201 or EC 205.
 An analysis of organization, market structure, and competitive behavior in specific industries, using the tools of the economist as a guide to pertinent factors and their significance. The course will be organized along the lines of intensive but broadly-relevant case-studies.
- EC 411. Marketing Methods** 3-0
 Prerequisite: EC 201 or EC 205.
 Marketing institutions and their functions and agencies; retailing; market analysis; problems in marketing.
- EC 412. Sales Management** 0-3
 Prerequisite: EC 411.
 Elements of sales management with emphasis on planning, operations, policies and programs.
- EC 413. Competition, Monopoly, and Public Policy** 3 or 3
 Prerequisite: EC 201 or EC 205. EC 301 recommended but not required.
 An analysis of the effect of modern industrial structure on competitive behavior and performance, in the light of contemporary price theory and the theory of workable competition. A critical evaluation of the legislative content, judicial interpretation, and economic effects of the antitrust laws.
- EC 414. Tax Accounting** 3 or 3
 Prerequisite: EC 312 or EC 401
 An analysis of the Federal tax laws relating to the individual and business. Determining and reporting income. Payroll taxes and methods of reporting them. Actual practice in the preparation of income tax returns.
- EC 415. Advertising** 2 or 2
 Prerequisite: EC 201 or EC 205.
 Principles of advertising; purposes; preparation of copy; media; advertising campaigns; legislation.
- EC 420. Corporation Finance** 3 or 3
 Prerequisite: EC 201 or EC 205.
 Financial instruments and capital structure; procuring funds; managing working capital; managing corporate capitalization; financial institutions and their work.
- EC 425. Industrial Management** 3-0
 Prerequisite: Junior standing.
 Principles and techniques of modern scientific management; relation of finance, marketing, industrial relations, accounting, and statistics to production; production planning and control; analysis of economic, political and social influences on production.
- EC 426. Personnel Management** 0-3
 Prerequisite: Junior standing.
 The scientific management of manpower, from the viewpoint of the supervisor and the personnel specialist. A study of personnel policy and a review of the scientific techniques regarding the specific problems of employment, training, promotion, transfer, health and safety, employee services, and joint relations.
- EC 431. Labor Problems** 3 or 3
 Prerequisite: Junior standing.
 An economic approach to labor problems including wages, hours, working conditions, insecurity, substandard workers, minority groups, social security, and public policy relative to these problems.
- EC 432. Industrial Relations** 3 or 3
 Prerequisite: Junior standing.
 Collective bargaining. Analysis of basic labor law and its interpretation by the courts and governmental agencies. An examination of specific terms of labor contracts and their implications of labor and management. An examination of labor objectives and tactics and management objectives and tactics. Problems of operating under the labor contract.
- EC 440. Economics of Growth** 3 or 3
 Prerequisite: EC 201 or EC 205.
 An examination of the institutional background required for national economic development. The conditions apparent for past growth of nations are compared with conditions obtaining in presently retarded nations. Conclusions are drawn from this comparison to provide an introduction to theoretical models of growth.
- EC 442. Evolution of Economic Ideas** 3 or 3
 Prerequisite: EC 201 or EC 205.
 An analysis of the development of economic thought and method during the past two centuries. Economics considered as a cumulative body of knowledge, in a context of emerging technology, changing institutions, pressing new problems, and the growth of science.
- EC 444. Economic Systems** 3 or 3
 Prerequisite: EC 201 or EC 205.
 A comparative analysis of the functioning of the major economic systems, with em-

phasis upon the ways in which the problem of economic decision-making is approached in a variety of economic settings.

EC 446. Economic Forecasting 3 or 3

Prerequisite: EC 201 or EC 205. EC 302 recommended but not required.

An examination of the basic principles and techniques of economic forecasting with strong emphasis upon the economic models upon which forecasting is based.

EC 448. International Economics 3 or 3

Prerequisite: EC 201 or EC 205.

A study of international economics, including trade, investment, monetary relations, and certain aspects of economic development. Emphasis upon analytical and policy approaches, although some institutional material is included.

EC 450. Economic Decision Processes 3 or 3

Prerequisites: EC 201 or EC 205 and Math 202 or Math 212.

An analysis of processes for decision making by individuals and groups. Linear programming, probability, and game theory in the light of a general theory of decision.

EC 461. (HI 461 or PS 461) The Soviet Union 0-3

Prerequisites: One semester of Economics and PS 201 or HI 205 or acceptable substitute.

An analysis of the structure and function of the major Soviet economic, political and social institutions with special stress on the historical roots and continuity of Russian civilization. The course is presented in three equal phases of approximately five weeks each, covering Russian history, Soviet government and Soviet economy.

EC 490. Senior Seminar in Economics 3 or 3

Prerequisite: Consent of Instructor

The terminal course in undergraduate study of economics. The student is assisted in summarizing his training, and in improving his capacity to recognize problems and to select logically consistent means of solving the problems. This is done on a small-group and individual basis.

Courses for Graduates and Advanced Undergraduates

EC 501 (AGC 501). Intermediate Economic Theory 3 or 3

Prerequisite: EC 301 or AGC 212, or equivalent.

An intensive analysis of the determination of prices and of market behavior, including demand, costs and production, pricing under competitive conditions, and pricing under monopoly and other imperfectly competitive conditions. Messrs. Bunting, Garb, Park, Shen.

EC 502. Money, Income, and Employment 3 or 3

Prerequisite: EC 302 or EC 501, or equivalent.

A study of the methods and concepts of national income analysis with particular reference to the role of monetary policy in maintaining full employment without inflation. Messrs. Bunting, Garb, Olsen.

EC 503. Advanced Accounting 3 or 3

Prerequisites: EC 201 or EC 205, and EC 401, 402.

Problems of asset valuation, such as depreciation, replacements, amortization, etc., as found in all types of business organizations; branch accounting, consolidations, installment selling. Messrs. Fails, Shulenberger.

EC 504, 505. Principles of Cost Accounting 3-3

Prerequisites: EC 201 or EC 205 and EC 401, 402.

Cost finding, materials costs, labor costs, overhead costs, etc., with an introduction to standard cost precedures. Mr. Shulenberger.

EC 510 (PS 510). Public Finance 3 or 3

Prerequisite: EC 201 or EC 205.

A survey of the theories and practices of governmental taxing, spending, and borrowing, including intergovernmental relationships and administrative practices and problems. Mr. Block.

EC 515. Investments

0-3

Prerequisite: EC 201 or EC 205.

Types of investment; investment market; investment analysis; investment channels; investment fluctuations; investment policies and practices.
Staff.

EC 525. Management Policy and Decision Making

3 or 3

Prerequisites: 9 hours in Economics and related courses and consent of the instructor.

A review and consideration of modern management processes used in making top-level policies and decisions. An evaluation of economic, social and institutional pressures, and of the economic and non-economic motivations, which impinge upon the individual and the organization. The problem of coordinating the objectives and the mechanics of management is examined.
Messrs. Bartley, Wood.

EC 531. Management of Industrial Relations

3 or 3

Prerequisites: 9 hours in Economics and related courses and consent of the instructor.

A seminar course designed to round out the technical student's program. Includes a survey of the labor movement organization and structure of unions, labor law and public policy, the union contract, the bargaining process, and current trends and tendencies in the field of collective bargaining.
Messrs. Bartley, Wood.

EC 550. Mathematical Models in Economics

3 or 3

Prerequisites: EC 201 or EC 205 and MA 202 or MA 212. EC 450 recommended but not required.

An introductory study of economic models emphasizing their formal properties. The theory of individual economic units is presented as a special case in the theory of inductive behavior. Mathematical discussions of the theory of the consumer, the theory of the firm, and welfare economics will show the relevance of such topics as constrained maxima and minima, set theory, partially and simply ordered systems, probability theory, and game theory to economics.
Mr. Harrell.

EC 552. Econometrics

3 or 3

Prerequisites: EC 201 or EC 205 and MA 202 or MA 212 and MA 405.

Recent developments in the theory of production, allocation, and organization. Optimal combination of integrated productive processes within the firm. Applications in the economics of industry and of agriculture.
Mr. Harrell.

EC 590, 591. Seminar in Special Economic Topics

3 or 3

Prerequisite: Consent of instructor.

Topics presented by a visiting professor or special lecturer. This course will be offered from time to time as distinguished visiting scholars are available.

Courses for Graduates Only**EC 601. Advanced Economic Theory**

3 or 3

Prerequisite: EC 501, or equivalent.

A rigorous examination of contemporary microeconomic theory.

Messrs. Bunting, Garb, Swanson.

EC 602. Monetary and Employment Theory 3 or 3

Prerequisite: EC 502, or equivalent.

The course consists of an analysis of the forces determining the level of income and employment; a review of some of the theories of economic fluctuations; and a critical examination of a selected macroeconomic system.

Messrs. Garb, Olsen, Swanson.

EC 603. History of Economic Thought 3 or 3

Prerequisite: EC 442 or EC 501, or equivalent.

A systematic analysis of the development and cumulation of economic thought, designed in part to provide a sharper focus and more adequate perspective for the understanding of contemporary economics.

Messrs. Olsen, Hickman.

EC 605. Research in Economics Credits by arrangement

Prerequisite: Graduate standing.

Individual research in economics, under staff supervision and direction.
Staff.

EC 640. Theory of Economic Growth 3 or 3

Prerequisite: EC 440 or EC 502, or equivalent.

Several theoretical models of economic growth are compared and analyzed. Contemporary developments in the theory of national economic growth are studied and evaluated for consistency with older theories. Mr. Olsen.

EC 648. Theory of International Trade 3 or 3

Prerequisite: EC 448 or EC 501, or equivalent.

A consideration, on a seminar basis, of the specialized body of economic theory dealing with the international movement of goods, services, capital, and payments. Also, a theoretically-oriented consideration of policy.

Mr. Hickman.

EC 650. Economic Decision Theory 3 or 3

Prerequisites: EC 501 or equivalent; EC 550 or EC 555.

Study of general theories of choice. Structure of decision problems; the role of information; formulation of objectives. Current research problems.

Mr. Harrell.

EC 655. Topics in Mathematical Economics 3 or 3

Prerequisites: EC 501 or equivalent; EC 550 or EC 555.

A seminar and research course devoted to recent literature and developments in mathematical economics.

Mr. Harrell.

EC 665. Economic Behavior of the Organization 3 or 3

Prerequisites: EC 501 or equivalent, and consent of instructor.

This seminar will apply methods and findings derived from the behavioral sciences to the economic behavior of the organization, particularly the business firm. Among the approaches which may be utilized are organization theory, information theory, reference group theory, and decision theory.

Messrs. Harrell, Hickman, Swanson.

SCHOOL OF EDUCATION

Graduate Faculty

Professors: JAMES BRYANT KIRKLAND, Dean, ROY NELS ANDERSON, KEY LEE BARKLEY, HAROLD MAXWELL CORTER, THOMAS I. HINES, IVAN HOSTETLER, HOWARD G. MILLER, CLARENCE CAYCE SCARBOROUGH.

Associate Professors: JOHN O. COOK, GERALD BLAINE JAMES, J. CLYDE JOHNSON, CHARLES G. MOREHEAD, SLATER E. NEWMAN, PAUL JAMES RUST, TALMAGE B. YOUNG.

The School of Education offers graduate programs leading to the Master's degree in Agricultural Education, Industrial Arts Education, Industrial Education, Occupational Information and Guidance, and Industrial Psychology. Graduate students in education may pursue programs leading to the Master of Science degree or to the Master's degree in a professional field. Both degrees are recognized by the State Department of Education.

The Master of Science Degree

The Master of Science degree is regarded as a research degree and as preparation for further graduate study. Programs leading to the Master of Science degree are planned to include a major (20 credit hours) in some specialized area of education and a minor (10 or more credit hours) in some other field such as psychology or agricultural economics. If two minors are chosen, a minimum of 6 credits will be required in each.

A reading knowledge of one modern foreign language is required.

A thesis representing an original investigation in the major field must be prepared.

The Master's Degree in a Professional Field.

The professional degree is designed to meet the needs of students who are preparing themselves for teaching in the secondary schools. The program of study meeting the requirements for this degree differs from that expected for the Master of Science in that a wider latitude is permitted in the choice of course work outside the major.

A problem may be substituted for a thesis if, in the opinion of the student's advisory committee, this alternative contributes maximally to the student's objective.

A knowledge of a foreign language is not required to meet the requirements for the professional degree.

A total of at least thirty credit hours is required, at least eight hours of which must be in course work at the 600 level. Not more than six semester hours will be accepted at the 400 level and all of these must fall outside of the major field.

Research Facilities

The School of Education is located in Tompkins Hall where well equipped laboratories and research facilities are provided for graduate study.

The Department of Industrial Arts has a well equipped laboratory for students to secure practical experience and to carry out experimental and research programs. The laboratory has been rated as one of the best in the Southeast. In addition, the Department utilizes the industrial arts facilities of the public schools for research work.

The Department of Psychology carries on its major research and service activities through the Industrial Psychology Center. The Center is staffed and equipped to provide general industrial psychology research and services such as personnel selection, personnel evaluation, attitude surveys, organization planning, management and supervisory training and other industrial psychology research and service activities. The Department also maintains an applied experimental laboratory in which graduate training and research are carried on.

The Department of Occupational Information and Guidance utilizes the facilities of the public schools, Public Employment Bureau, business and industrial establishments, Welfare Agencies and Vocational Rehabilitation Centers as laboratories in which students can acquire practical experience while working for the Master's degree.

The Department of Agricultural Education utilizes the resources of the School of Agriculture and the Experiment Station. Problems of the local school community provide the basis for much of the research in Agricultural Education.

Holders of advanced degrees in education are much in demand to fill responsible positions in the secondary school system of the State. Teachers with advanced degrees qualify for Graduate Teacher's Certificates which automatically place them in higher salary brackets.

GENERAL COURSES

Courses for Graduates and Advanced Undergraduates

ED 501. Education of Exceptional Children 3-0

Advanced undergraduates or graduates. Prerequisite: six hours in education or psychology.

Discussion of principles and techniques of teaching the exceptional child with major interest on the mentally handicapped and slow learner. Practice will be given in curriculum instruction for groups of children, individual techniques for dealing with retarded children in the average classroom. Opportunity for individual work with an exceptional child will be provided.

Mr. Corter.

ED 502. Analysis of Reading Abilities 3 or 3

Prerequisites: Six hours in education or psychology.

A study of tests and techniques in determining specific abilities; a study of reading retardation and factors underlying reading difficulties.

Mr. Rust.

ED 503. Improvement of Reading Abilities 3 or 3

Prerequisites: Six hours of education or psychology.

A study of methods used in developing specific reading skills or in over-

coming certain reading difficulties; a study of methods used in developing pupil vocabularies and work analysis skills; a study of how to control vocabulary burden of reading material. Mr. Rust.

ED 505. Group Dynamics in Teaching 3

Prerequisites: Six hours in education or psychology.

A study of group methods in teaching with special reference in role playing, conference techniques, and group dynamics in their application to teaching and an understanding of the student's behavior. Mr. Miller.

ED 509. Workshop in Special Education Maximum 6 Credits

Prerequisite: ED 501 and six hours in Psychology (Summer only)

The workshop in Special Education provides opportunity for group projects in all aspects of special education, and group participation in development of individual projects. Public relations, library facilities, occupational surveys, methods and materials, development of new programs, units of work and room planning are examples of projects. Project materials are collected, mimeographed, and distributed to class members to serve as a handbook for future use. Materials are frequently tried out in the practicum. Specific subject matter areas to meet formal certification requirements for special education are also taught in small groups.

Mr. Corter.

ED 510. Advanced Driver Education 3 (Summer only)

Prerequisite: Ed 410.

The study of course content in present day driver education courses: Evaluation of research literature in driver education; a study of existing driver education programs at both secondary and college levels; and evaluation of psychological and educational research in accidents.

ED 552. Industrial Arts in the Elementary School 3 (Summer only)

Prerequisites: Twelve credits in education and consent of instructor.

This course is organized to help elementary teachers and principals understand how tools and materials and industrial processes may be used to vitalize and supplement the elementary school children's experiences. Practical children's projects along with the building of classroom equipment.

Mr. Hostetler.

ED 563. Effective Teaching 3 or 3

Prerequisite: Twelve hours in Education.

Analysis of the teaching-learning process; assumptions that underlie course approaches; identifying problems of importance; problem solution for effective learning; relationship of learning and doing; responsibility for learnings; evaluation of teaching and learning; making specific plans for effective teaching.

Messrs. James, Scarborough.

Courses for Graduates Only

ED 614. Modern Principles and Practices in Secondary Education 2 or 2

Prerequisite: Twelve hours in Education.

Foundations of modern programs of secondary education; purposes,

curriculum, organization, administration, and the place and importance of the high school in the community in relation to contemporary social force.

Graduate Staff.

ED 615. Introduction to Educational Research

3-0

Prerequisite: Twelve hours in Education.

An introductory course for students preparing for an advanced degree. The purposes are: to assist the student in understanding the meaning and purpose of educational research and the research approach to problems; to develop students' ability to identify educational problems, and to plan and carry out research to solve these problems; to aid in the preparation of the research report. Special attention is given to tools and methods of research. Consideration is also given to the educator as a consumer of research.

Graduate Staff.

ED 665. Supervising Student Teaching

3 or 3

Prerequisite: Twelve hours in Education.

A study of the program of student teaching in teacher education. Special consideration will be given the role of the supervising teacher including the following areas: planning for effective student teaching, observation and orientation, school community study, analysis of situation, evaluating student teacher, and coordination with State College.

Graduate Staff.

AGRICULTURAL EDUCATION

Courses for Graduates and Advanced Undergraduates

ED 554. Planning Programs of Vocational Agriculture

3 or 3

Prerequisite: ED 411.

Consideration of the community as a unit for planning programs in agricultural education; objectives and evaluation of community programs; use of advisory groups; school and community relationships; organization of the department and use of facilities.

Messrs. Scarborough and James.

ED 558. Special Problems in Teaching

Max. 6

Prerequisite: ED 411.

Credits.

Current problems in agricultural education. Opportunities for students to study particular problems under the guidance of the staff.

Graduate Staff.

ED 563. Effective Teaching

3 or 3

Prerequisite: Twelve hours in Education.

Analysis of the teaching-learning process; assumptions that underlie course approaches; identifying problems of importance; problem solution for effective learning; evaluation of teaching and learning; making specific plans for effective teaching.

Messrs. James, Scarborough.

ED 568. Adult Education in Agriculture

3 or 3

Prerequisite: ED 411.

This course is designed to meet the needs of teachers as leaders in adult

education. More emphasis is being given to working with adults as part of the community program of vocational agriculture. This course will give the teacher an opportunity to study some of the basic problems and values in working with adult groups. Particular attention will be given to the problem of fitting the educational program for adults into the high school program of vocational agriculture, as well as to methods of teaching adults.

Messrs. Scarborough and James.

Courses for Graduates Only

ED 616. Advanced Problems in Agricultural Education 3 or 3

Prerequisite: ED 558.

Group study in current and advanced problems in the teaching and administration of agricultural education; evaluation of procedures and consideration for improving. Graduate Staff.

ED 617. Philosophy of Agricultural Education 3 or 3

Prerequisite: ED 554.

An examination of current educational philosophies and their relation to agricultural education. Principles and practices involved in the leadership of a teacher of agriculture and in making his work effective in a rural community. Study of leaders in the field. Mr. Scarborough.

ED 618. Seminar in Agricultural Education Max. 2 credits

A critical review of current problems, articles, and books of interest to students of agricultural education. Graduate Staff.

ED 621. Research in Agricultural Education Max. 6 credits

Individual direction in research on a specific problem of concern to the student. Generally, the student is preparing his thesis or research problem. Graduate Staff.

ED 664. Supervision in Agricultural Education 3 or 3

Prerequisite: ED 563.

Organization, administration, evaluation and possible improvement of present supervisory practice; theory, principles and techniques of effective supervision in agricultural education at different levels.

Messrs. Kirkland, Scarborough.

ED 665. Supervising Student Teaching

(See description on p. 82)

INDUSTRIAL ARTS AND INDUSTRIAL EDUCATION

Courses for Graduates and Advanced Undergraduates

IA 510. Design for Industrial Arts Teachers 3 or 3

Prerequisite: 6 hours of Drawing and IA 205 or equivalent.

A study of new developments in the field of design with emphasis on

the relationship of material and form in the selection and designing of industrial arts projects. Graduate Staff.

ED 516. Community Occupational Surveys 0-2

Prerequisites: Six credits in Education and consent of instructor.

Methods in organizing and conducting local surveys and evaluation of findings in planning a program of vocational education.

Graduate Staff.

ED 521. Organization of Related Study Materials 2 or 2

Prerequisite: ED 422.

The principles of selecting and organizing both technical and general related instructional material for trade extension and diversified occupations classes.

Graduate Staff.

ED 525. Trade Analysis and Course Construction 2-0

Prerequisites: ED 344 PSY 304.

Principles and practices in analyzing occupations for the purpose of determining teaching content. Practice in the principles underlying industrial course organization based on occupational analysis covering instruction in skills and technology and including course outlines, job sequences, the development of industrial materials and instructional schedules.

Graduate Staff.

ED 527. Philosophy of Industrial Education 0-2

Prerequisite: ED 422.

A presentation of the historical development of industrial education; the philosophy of vocational education; study of Federal and State legislation pertaining to vocational education; types of programs, trends and problems.

Graduate Staff.

ED 528. Principles and Practices in Diversified Occupations 2 or 2

Prerequisite: ED 422.

A study of the development, the objectives, and principles of diversified occupations. The organization, promotion and management of programs in this area of vocational education.

Graduate Staff.

ED 552. Industrial Arts in the Elementary School 3 or 3

(See description on page 81).

IA 570. Laboratory Problems in Industrial Arts Max. 6

Prerequisites: Senior standing and permission of instructor.

Courses based on individual problems and designed to give advanced majors in industrial arts education the opportunity to broaden or intensify their knowledge and abilities through investigation and research in the various fields of industrial arts, such as metals, plastics, or ceramics.

Graduate Staff.

IA 575. Special Problems in Industrial Arts Max. 6

Prerequisite: One term of student teaching or equivalent.

The purpose of these courses is to broaden the subject matter experiences in the areas of industrial arts. Problems involving experimentation,

investigation and research in one or more industrial arts areas will be required. Graduate Staff.

IA 580. Modern Industries 2-2

Prerequisites: Twelve credits in Industrial Arts and consent of the instructor

Elective course for advanced undergraduate and graduate students in industrial arts. Designed to assist teachers in guiding students to sources of information relative to various modern industries. Mr. Young.

ED 595. Industrial Arts Workshop 3 (Summer only).

Prerequisite: One or more years of teaching experience.

A course for experienced teachers, administrators and supervisors of industrial arts. The primary purpose will be to develop sound principles and practices for initiating, conducting and evaluating programs in this field. Enrollees will pool their knowledge and practical experiences and will do intensive research work on individual and group problems.

Courses for Graduates Only

ED 610. Administration and Supervision of Vocational Education 2 or 2

Prerequisites: PSY 304, ED 344, 420, 440, or equivalent.

Administrative and supervisory problems of vocational education; practices and policies of Federal and State offices; organization and administration of city and consolidated systems. Graduate Staff.

ED 614. Modern Principles and Practices in Secondary Education.

(See description on p. 81).

ED 619. Seminar in Industrial Arts Education 1-1

Prerequisite: Graduate Standing.

Presentation of current literature in the field of Industrial Arts Education; review and discussion of student papers and research problems.

Mr. Hostetler.

ED 624. Research in Industrial Arts Education Max. 6

Prerequisites: Eighteen credits in Education and permission of instructor.

The student will be guided in the selection of one or more research problems and in the organization of the problems, methods of gathering data, procedure for analyzing data, and the best practice for interpreting and reporting data.

Mr. Hostetler.

ED 627. Research in Industrial Education Max. 6

Prerequisites: Eighteen credits in Education and permission of instructor.

The student will be guided in the selection of one or more research problems and in the organization of the problems, methods of gathering data, procedure for analyzing data, and best practice for interpreting and reporting data.

Graduate Staff.

ED 630. Philosophy of Industrial Arts 2 or 2

Prerequisite: Twelve hours in Education.

Required of all graduate students in Industrial Arts Education.

Current and historical developments in industrial arts; philosophical

concepts, functions, scope, criteria for the selection and evaluation of learning experiences, laboratory organization, student personnel programs, community relationships, teacher qualifications, and problems confronting the industrial arts profession. Mr. Hostetler.

ED 635. Administration and Supervision of Industrial Arts 2 or 2

Prerequisite: Twelve hours in Education.

A study of the problems and techniques of administration and supervision in the improvement of industrial arts in the public schools. Selection of teachers and their improvement in service and methods of evaluating industrial arts programs. Mr. Hostetler.

OCCUPATIONAL INFORMATION AND GUIDANCE

Special facilities are provided in the School of Education for mature students and individuals who have had teaching or personnel experience and who hold a Bachelor's Degree to enroll for courses leading to a Master's Degree in Occupational Information and Guidance, or a Master of Science Degree in this area. Graduate work in Occupational Information and Guidance gives preparation for such positions as counselor in secondary schools, colleges, or community agencies; school guidance director; employment counselor; placement workers; business or industrial personnel worker; and for personnel work in the State and Federal Government. Administrators, supervisors, directors of instruction, and others who may wish to prepare themselves for positions of leadership in guidance work may also utilize this graduate program.

The offerings of the Department of Occupational Information and Guidance enable graduate students in teaching areas to select appropriate guidance courses which will enable them to provide guidance and counseling for their pupils, as well as to exert influence in promoting a school-wide guidance program.

The Master's program includes a core of Guidance courses as follows: Ed. 524, *Occupational Information*; Ed. 533, *Organization and Administration of Guidance Services*; Ed. 631, *Educational and Vocational Guidance*; Ed. 633, *Techniques in Guidance and Personnel*; Ed. 641, *Field Work*; and Ed. 651, *Research*. In addition to the core courses, the typical program for school counselors includes Psy. 530, *Abnormal Psychology*, Psy. 535, *Tests and Measurements*, Psy 571, *Intelligence: Theory and Measurement*, ED. 530, *Group Guidance*, and Ed. 615, *Introduction to Educational Research*. Opportunity for field work is available in secondary schools, colleges, clinics, and employment offices, and other agencies, according to the student's interest. Courses in Psychology, Sociology, Economics, and Education are selected to round out the program. In addition to meeting the requirements for the Master's degree, the program also meets the requirements for the Counselor's Certificate issued by the State Department of Public Instruction, as well as similar certificates in many other states.

In addition to the graduate program, the Department provides instruction in guidance for undergraduate students in the School of Education.

Vocational Rehabilitation Counseling

A new program made possible by a grant from the Office of Vocational Rehabilitation of the Department of Health, Education and Welfare, and begun in the Spring of 1955, provides for the training of vocational rehabilitation counselors. In this program an interdisciplinary approach is used, with students taking the basic core of guidance courses enumerated above, and rounding out their programs with course work in the Department of Psychology, Sociology, Economics. Several new courses, designed especially for the preparation of rehabilitation counselors, are offered in the Department of Occupational Information and Guidance, and also in other departments on the campus: Education 531, Introduction to Vocational Rehabilitation, Ed. 532, Medical Information for Rehabilitation Counselors, and Sociology 505, Sociology of Rehabilitation in the Department of Sociology.

Part of the counselor training consists of an internship to be served in one of the various types of public or private agencies that provide counseling services to the handicapped. The student has the opportunity to select an internship setting according to his own interests.

The Department of Occupational Information and Guidance has received eighteen scholarships of \$1800 each to be awarded as Traineeship Grants in the program sponsored by the Office of Vocational Rehabilitation. These scholarships are provided for the purpose of increasing the number of qualified workers in the area of rehabilitation.

Individuals qualified to provide vocational counseling for the handicapped are in great demand at the present time, and the future demand will be even greater. The impetus to rehabilitation services given by the Office of Vocational Rehabilitation will result in numerous occupational opportunities for those who have an interest in helping handicapped persons to become vocationally self sufficient.

Application forms for these scholarships may be secured from Dr. Roy N. Anderson, Head, Department of Occupational Information and Guidance, School of Education.

Courses for Advanced Undergraduates

ED 420. Principles of Guidance

2-2

Prerequisites: PSY 304, PSY 476, student teaching or equivalent.

This is a course designed to provide basic principles of guidance for teachers, teacher-counselors, administrators, and others in the school, as well as workers in other areas such as the community agency, business, industry, group work, and the like. Among the topics covered are: need for guidance; basis of guidance services; programs of guidance; studying the individual; counseling for educational, vocational, social, and personal problems; group procedures in guidance. Emphasis is on the practical application of guidance principles and procedures.

Mr. Morehead.

ED 424. Occupational Studies

0-2

Designed for majors in Industrial Arts and Vocational Education and emphasizing industrial occupations. Uses of educational and occupational information, sources, preparation and interpretation of occupational materials. Occupational and industrial structure; local and national trends, occupations in selected industries. Labor legislation, Job adjustment and satisfaction. Providing occupational information to individuals and groups.

Mr. Morehead.

Courses for Graduates and Advanced Undergraduates

ED 524. Occupational Information 0-3

Prerequisites: 6 hours of education or psychology and ED 420 or equivalent.

This course is designed to prepare teachers, counselors, business and industrial personnel workers, placement workers, and others to collect evaluate, and use occupational and educational information. In addition to the study of the usual sources and types of published occupational information, attention will be given to collection of occupational information locally, preparation of the occupational monograph, analysis of job requirements and worker characteristics, occupational trends and factors affecting trends, occupational and industrial structure and classification, and the like. Imparting occupational information to groups and individuals by techniques such as the following are considered: The occupations unit in social studies and other courses, the occupations course, home-room activities, introducing occupational information informally in subject matter courses, the resource file, vocational counseling. Mr. Morehead.

ED 530. Group Guidance 0-3

Prerequisites: 6 hours of education or psychology and ED 420 or equivalent.

This course is designed to help teachers, counselors, administrators, and others who work with groups or who are responsible for group guidance activities, to understand the theory and principles of effective group work, to develop skill in using specific guidance techniques, and to plan and organize group activities in the secondary school and other institutions. The relationship of group activities to counseling and other aspects of guidance services is considered. Methods of evaluating and improving group guidance activities are taken up. Mr. Morehead.

ED 531. Introduction to Vocational Rehabilitation 3-0

Prerequisites: 6 hours from following fields—Economics, Education, Psychology or Sociology.

This course will serve as an introduction to the broad field of rehabilitation services and programs directed toward the restoration of physically and/or mentally disabled persons into employment. The course will emphasize the State-Federal, and private agency programs. It will be interdisciplinary in its approach covering the areas of social work, medicine, psychology, sociology and economics. Specialists or appropriate persons in the above areas will be invited to participate. Field trips to agencies will be required. Mr. Anderson.

ED 532. Medical Information for Rehabilitation Counselors 3-0

Prerequisite: Advanced graduate standing.

This course is designed for Vocational Rehabilitation Counselors and other workers in rehabilitation. The course will provide counselors with the necessary background in medical information and terminology so that they can understand and interpret medical information in the integrated rehabilitation process. The course will consist of lectures by medical specialists who will present the methods of diagnosis, treatment, and the re-

habilitation aspects of disabling conditions. Visits will be made to clinics.
Mr. Anderson.

ED 533. Organization and Administration of Guidance Services 3-0
Prerequisites: Graduate standing and ED 420 or equivalent.

This course is designed for school guidance workers and those preparing for this field. Basic principles and current practices employed in developing, organizing, administering, and supervising guidance services in the elementary and secondary school will be studied. Interrelationship of guidance services with instruction, administrative relationships, utilization of school staff, and evaluation of guidance services will be considered.
Mr. Morehead.

ED 590. Individual Problems in Guidance 3-3
Prerequisites: 6 hours graduate work in Department or equivalent.

Intended for individual or group studies of one or more of the major problems in Guidance and Personnel work. Problems will be selected to meet the interests of individuals. The workshop procedure will be used whereby special projects and reports will be developed by individuals and by groups.
Messrs. Anderson, Morehead.

Courses for Graduates Only

ED 631. Educational and Vocational Guidance 3-0
Prerequisites: 9 hours from following fields—Economics, Education, Psychology or Sociology.

This course aims to provide training for teachers who are part-time or full-time counselors, employment interviewers, social workers and personnel workers, who are aiding individuals with vocational adjustment problems. The course will cover the functions performed in vocational and educational guidance such as assembling and imparting occupational information, counseling regarding vocational and educational plans, the use of aptitude tests, placement in jobs and follow-up, and procedures in setting up services of vocational and educational guidance in schools, employment offices, and social service agencies.
Mr. Anderson.

ED 633. Techniques in Guidance and Personnel 0-3
Prerequisites: 9 hours from following fields—Economics, Education, Psychology or Sociology.

This course is designed to aid personnel workers in secondary schools, colleges, employment offices, and social agencies to develop an understanding and to develop skill in using various guidance and personnel techniques. Some of the techniques to be studied intensively are: anecdotal reports, rating scales, observation, records and reports, sociograms, interviewing, counseling and case study procedures. Students will become acquainted with these techniques through lectures, demonstrations, and the study of case histories. Attention will be given to both diagnosis and treatment.
Mr. Anderson.

ED 641. Field work in Occupational Information and Guidance 2 to 6
Prerequisite: Advanced graduate standing.

A practicum course in which the student undertakes field work in secondary schools, colleges, social service agencies, employment office, and industrial establishments which carry on guidance and personnel work. The student may observe and participate in some personnel service and may study the organization and administration of the programs.

Messrs. Anderson, Morehead.

ED 651. Research in Occupational Information and Guidance Maximum
Prerequisite: Advanced graduate standing. 6 credits

Qualified students will conduct investigations and research in Guidance and Personnel. Published reports and techniques in investigation will be analyzed and evaluated.

Messrs. Anderson, Morehead.

PSYCHOLOGY

See Psychology

DEPARTMENT OF ELECTRICAL ENGINEERING

Graduate Faculty

Professors: GEORGE BURNHAM HOADLEY, Head, WILLIAM JOHN BARCLAY, JOHN HAROLD LAMPE, WILLIAM DAMON STEVESON, JR.

Associate Professors: NORMAN ROBERT BELL, WILBUR CARROLL PETERSON.

The graduate degrees offered by the Department of Electrical Engineering are the Master of Science (M.S.) and the Doctor of Philosophy (Ph.D.)

Graduate work in Electrical Engineering at the first-year or master's level divides naturally into fields such as electronics, automatic control, computers, and power systems. In the more advanced study required for the doctorate, however, this distinction tends to disappear.

Advanced courses of a general and fundamental nature, such as Electric Network Synthesis and Advanced Electromagnetic Theory, are recommended for all graduate students in Electrical Engineering, especially those who plan to carry their advanced studies to the level of the doctorate. Minor sequences of study in advanced mathematics or physics are planned to fit the needs of individual students.

Holders of graduate degree in electrical engineering at North Carolina State College are in continual demand. Alumni hold important positions in industrial, government, and university research laboratories, in the teaching profession, and in the administrative and engineering departments of manufacturing corporations and public utilities.

Courses for Advanced Undergraduates

EE 414. Electronics

0-4

Prerequisites: EE 301, PY 407.

A study of the fundamentals of electrical conduction in vacuum, gases, and solids. Operating characteristics of vacuum and gaseous tubes, mercury arc rectifiers, photoelectric cells, cathode-ray tubes and solid state devices. Introduction to electronic circuit theory. One laboratory period a week illustrates the theory covered during lecture and recitation periods.

Mr. Thompson.

EE 430. Essentials of Electrical Engineering

4-0

Prerequisites: MA 301, EE 332.

Not available to undergraduates in electrical engineering.

Essential theory of electric circuits, including electron tubes, solid state devices, transformers and rotating machines as needed to supply the electrical background for instrumentation and control theory. Intended primarily for graduate students who do not have an electrical engineering undergraduate degree. Mr. Manning.

Courses for Advanced Undergraduates and Graduates

EE 501. Advanced Circuits and Fields I 3-0
Prerequisites: EE 302, MA 301.

Transient analysis of electric circuits by the Laplace transform method. The study of transient and sinusoidal steady-state response in terms of poles and zeros of network functions. Mr. Stevenson.

EE 502. Advanced Circuits and Fields II 0-3
Prerequisites: EE 302, MA 301.

A study of classical electric and magnetic field theory and its application to the problems of electrical engineering. Consideration of electrostatics, magnetostatics, radiation, and guided waves, using vector methods. Mr. Mott.

EE 511. Electronic Engineering 3-0
Prerequisites: EE 302, EE 414.

Comprehensive coverage of circuits and equipment using electronic devices; variable frequency effects; amplifiers, oscillators, modulators, detectors, wave-shaping circuits, generators of non-linear waveforms; basic pulse techniques; principles of electronic analogue computers. Emphasis on quantitative analysis and engineering design. Mr. Barclay.

EE 512. Communication Engineering 0-3
Prerequisite: EE 511.

Application of electronic circuits and equipment to radio and wire communication systems. Elements of complete systems, wave propagation, antennas, transmitters, receivers, television, radar, electronic navigation systems, noise, special applications. Mr. Barclay.

EE 513. Electric Power Engineering 3-0
Prerequisites: EE 302, 305.

A study of industrial power supply and power factor correction; direct and alternating current motor characteristics, starting methods, dynamic braking and speed control; motor applications, and industrial control apparatus. Mr. Bell.

EE 514. Power System Analysis 0-3
Prerequisites: EE 302, 305.

Analysis of problems encountered in the long-distance transmission of electric power. Line parameters by the method of geometric mean distances. Circle diagrams, symmetrical components, and fault calculations. Elementary concepts of power system stability. Applications of digital computers to power-system problems. Mr. Stevenson.

EE 515. Elements of Control 3-0
Prerequisites: EE 414, EE 305.

Introductory theory of open and closed loop control. Functions and performance requirements of typical control systems and system components. Dynamic analysis of error detectors, amplifiers, motors, demodulators,

analogue components and switching devices. Component transfer characteristics and block diagram representation. Mr. Peterson.

EE 516. Feedback Control Systems 0-3
Prerequisites: EE 501, EE 515.

Study of feedback systems for automatic control of physical quantities such as voltage, speed and mechanical position. Theory of regulating systems and servo-mechanisms. Steady state and transient responses. Evaluation of stability. Transfer function loci and root locus plots. Analysis using differential equation and operational methods. System compensation and introduction to design. Mr. Peterson.

EE 517. Control Laboratory 0-1
Corequisite: EE 516.

Laboratory study of feedback systems for automatic control of physical quantities such as voltage, speed and mechanical position. Characteristics of regulating systems and servomechanisms. The laboratory work is intended to contribute to an understanding of the theory developed in EE 516, Feedback Control Systems. Mr. Peterson.

EE 518. Instrumentation and Control in Nuclear Technology 0-3
Prerequisites: EE 430, or EE 301, EE 305, EE 414; and MA 301.

Radiation detectors, pulse amplifiers, pulse shapers, amplitude discriminators, counters, coincidence circuits, reactor kinetics reactor simulators, automatic control of reactors. Mr. Manning.

EE 520. Fundamentals of Digital Systems 0-3
Prerequisites: EE 414 or EE 430.

The basic theory of digital computation and control. Introduction to number systems, data handling, relay algebra, switching logic, memory circuits, the application of electronic devices to switching circuits, and the design of computer control circuits. Mr. Bell.

Courses for Graduates Only

EE 605, 606. Electrical Engineering Seminar 1-1
Prerequisite: Graduate Standing in EE.

A series of papers and conferences participated in by the instructional staff, invited guests, and students who are candidates for advanced degrees. Graduate Staff.

EE 611, 612. Electric Network Synthesis 3-3
Prerequisite: EE 501.

A study of modern network theory, with the emphasis on synthesis, based on the work of Brune, Bode, Quillemin Bott and Duffin, Darlington, Foster and many others. Both the realization problem and the approximation problem will be treated. Mr. Hoadley.

EE 613. Advanced Feedback Control 0-3
Prerequisite: EE 516.

An advanced study of feedback systems for the control of physical variables. Analysis of follower systems and regulators. Mathematical and

graphical description of systems. Stability theory and performance criteria. Frequency response and root locus methods of analysis. System compensation and design. Introductory analysis of non-linear systems. Mr. Peterson.

EE 615. Electromagnetic Waves 4-0
Prerequisite: EE 502.

Maxwell's Equations applied to a study of the propagation of energy by electromagnetic waves. Vector and scalar potentials, retarded potentials, reflection and refraction, power flow and energy density; plane, rectangular and cylindrical wave guides; lines and cavity resonators. Laboratory on microwave techniques and measurements. Mr. Barclay.

EE 616. Microwave Engineering 0-4
Prerequisite: EE 615.

Analysis and design of microwave devices and systems. Theory and application of klystrons, magnetrons, traveling-wave tubes, masers, parametric amplifiers and other modern high-frequency devices.

Mr. Barclay.

EE 617. Pulse Switching & Timing Circuits 0-3
Prerequisites: EE 501, EE 512.

Tube and transistor circuit techniques for the production, shaping, and control of nonsinusoidal wave forms. Fundamental circuits needed in pulse information systems, instrumentation, and computers.

Mr. Barclay.

EE 618. Radiation and Antennas 4-0 or 0-4
Prerequisite: EE 615.

Electromagnetic wave theory applied to antennas and antenna arrays. Calculation and measurement of directional characteristics and field intensity

Mr. Barclay.

EE 621. Vacuum Electron Devices 0-3
Prerequisite: EE 615.

An intensive analytic study of the laws of electron emission and motion in electron tubes. Poisson's equation and conformal transformations are used to develop design criteria and formulae. Emission, space charge, beam formation and focussing, noise, tube parameters and ratings and construction techniques.

Mr. Barclay.

EE 637. Circuit Analysis of Power Systems 3-0
Prerequisite: EE 514.

An advanced treatment of symmetrical components applied to unsymmetrical systems, and simultaneous faults.

Mr. Stevenson.

EE 638. Power System Stability 0-3
Prerequisite: EE 514.

A study of the principal factors affecting stability and of the method of making stability calculations. Illustrations of studies made on actual power systems.

Mr. Stevenson.

EE 641. Advanced Digital Computer Theory 0-3
Prerequisite: EE 520.

A study of the circuits and components of modern digital computers, including basic logic systems, codes, advanced systems of circuit logic, vacuum tube, transistor, and magnetic components. Memory devices, counters, converters, adders, accumulators, inputs, outputs, and computer control systems will be analyzed.

Mr. Bell.

EE 643. Advanced Electrical Measurements

2-0

Prerequisites: EE 302, EE 414.

A critical analysis of circuits used in electrical measurements, with special attention to such topics as balance convergence, effects of strays, sensitivity, the use of feedback in electronic devices, and automatic measuring systems.

Mr. Hoadley.

EE 645, 646. Advanced Electromagnetic Theory

3-3

Prerequisites: EE 615 or PY 503; MA 541.

A comprehensive study of electricity and magnetism, emphasizing dynamic field theory. Potential theory, boundary-value problems, electrostatics and magnetostatics, transients in continuous systems, electromagnetic theory of light.

Mr. Mott.

EE 650. Electrical Engineering Research

Credits by
arrangement

Prerequisites: Graduate standing in EE and approval of adviser.

Graduate Staff.

EE 661, 662. Special Studies in Electrical Engineering

3-3

This course provides an opportunity for small groups of advanced graduate students to study, under the direction of qualified members of the professional staff, advanced topics in their special fields of interest.

Graduate Staff.

ENGINEERING HONORS

The Engineering Honors Program is a contribution by the faculty of the School of Engineering to the development of undergraduate students who have demonstrated outstanding ability by the end of their sophomore year. Administered by a committee with representatives from each engineering department, the program has as a specific goal the encouragement of these students to continue their studies at the graduate level.

Such students, during their two years of participation, follow individual programs of study selected to meet their needs and interests. The programs are made up around special courses developed for the Engineering Honors program, which reflect the ability of these students to benefit from advanced treatments of concepts essential to engineering advances. The special courses include offerings from such fields as thermodynamics, mechanics, electromagnetic systems, mathematics, and analysis; they are characterized by rigorous development of concepts and principles and emphasize their interdisciplinary nature.

E 500. Engineering Analysis

0-3

Prerequisites: Selection for Honor's Group Program and Senior Standing or Special Consent of Instructor.

This course is to be an experience involving both analysis and synthesis and making use of fundamental principles of science (especially physics and mathematics) and of engineering. The engineering situations to be studied are expected to cut across departmental lines and to involve elements of research. It is anticipated that sometimes two staff members or one staff member and an individual from industry (carefully chosen and briefed ahead of time) will participate in the class meetings; that the classes will be conducted by the discussion method; and that the studies will center around statements of engineering projects and the analysis and solution proffered by one or a team of students.

Engineering Graduate Staff.

DEPARTMENT OF ENGINEERING MECHANICS

Graduate Faculty

Professors: RALPH E. FADUM, Acting Head, ADOLPHUS MITCHELL.

The Department of Engineering Mechanics offers graduate work leading to the Master of Science degree in the fields of fluid mechanics, stress analysis, elasticity, and other areas in theoretical and applied mechanics. Students proficient in these subjects are in demand as investigators in machine or structural design, as teachers in engineering schools and as research members of large industrial companies.

Course for Advanced Undergraduates

EM 430. Fluid Mechanics

2 or 2

Prerequisite: EM 312 or EM 342.

Fluid statics, kinematics, Bernoulli equation, momentum, free-surface flow, viscosity, pipe friction, drag on submerged bodies, lift, elastic wave propagation.

Messrs. Clayton, Hardee, and Middleton.

Courses for Graduates and Advanced Undergraduates

EM 503. Theory of Linear Elasticity

3 or 3

Prerequisites: EM 321, MA 301.

The differential equation approach employed in development of the equations representing the behavior of a linear elastic solid. The elastic problem formulated in two and three dimensions and various coordinate systems. Application of the theory illustrated through selected problems.

Messrs. Douglas, Mitchell.

EM 511. Theory of Plates and Shells

3 or 3

Prerequisites: EM 321, MA 301.

A modern study of the theory of plates and shells. Topics are selected from problems involving membranes, folded plates, circular and rectangular slabs, domes, cylindrical shells and hyperbolic paraboloids. Solutions are obtained by both classical and modern numerical methods. Mr. Mitchell.

EM 531. Hydraulic Machinery

2 or 2

Prerequisite: EM 430.

Theory of lift and application to propellers, fans; blade theory including generalized Bernoulli equation, angular impulse, and angular momentum;

forced and free vortex; impulse, reaction, and propeller turbines; positive displacement pumps, centrifugal pumps; propagation in pipes and surge tanks; fluid couplings and torque converters. Mr. Middleton.

EM 551. Advanced Strength of Materials 3 or 3

Prerequisite: EM 312.

Stresses and strains at a point; rosette analysis; stress theories, stress concentration and fatigue; plasticity; inelastic, composite and curved beams; prestress; energy methods; shear deflections; buckling problems and column design; and membrane stresses in shells.

Messrs. Hardee, Mitchell.

EM 554. Theory of Vibrations 3 or 3

Prerequisites: EM 312 or 342; EM 321 or 343, MA 301.

Free vibrations without damping; natural frequency; forced vibrations without damping; balancing of rotating and reciprocating machinery; free vibrations with damping; forced vibrations with damping; vibration of systems with several degrees of freedom; shock and sound isolation; application of isolators.

Mr. Mitchell.

EM 556. Advanced Mechanics 3 or 3

Prerequisite: EM 312.

Virtual work; stability; balancing; elastic impact and waves; governors; LaGrangian equations of motion; three-dimensional dynamics of rigid body; gyroscopes; derivation from Kepler's laws of Newton's law of gravitation.

Mr. Clayton.

Courses for Graduates Only

EM 601. Applied Analysis in Strength of Materials 3 or 3

Prerequisites: EM 551; MA 301.

Advanced problems by energy methods. Difficult internal stress problems. Stresses in thin-webbed curved beams; stresses in square and curved knees of rigid frames; torsion in rolled profiles; design of beams for bending and torsion; equilibrium and compatibility in two dimensions; Airy's stress function; pure bending of plates; the plate equation; transverse and middle plane loads on plates. Beams on elastic foundations.

Mr. Mitchell.

EM 602. Theoretical and Applied Elasticity 3 or 3

Prerequisites: EM 321; MA 301.

Buckling by torsion and flexure; lateral instability of beams and beam-columns; tapered and built-up columns; local failures; the four-moment theorem; stresses in circular and rectangular plates; stress concentrations. In the above topics, theory is developed and the resulting equation solved by classical or numerical methods. Results are compared with leading design specifications.

Mr. Mitchell.

EM 604. Theory of Plasticity 3 or 3

Prerequisite: EM 503.

Development of the equations representing the plastic behavior of deformable solids. Yield conditions and plastic stress-strain relations. Plane-strain theory, hyperbolic equations and slip line fields. Selected problems to illustrate the theory.

Mr. Douglas.

EM 605. Research in Strength of Materials	3 to 6
Special problems and investigations.	Graduate Staff.
EM 606. Research in Mechanical Vibrations	3 to 6
Special problems and investigations.	Graduate Staff.
EM 607. Research in Fluid Mechanics	3 to 6
Special problems and investigations.	Graduate Staff.
EM 608. Advanced Fluid Mechanics	3 or 3
Prerequisite: EM 430.	
Potential motion; vortex theory; Navier-Stokes equations; theories of turbulence; theory of boundary layer; boundary separation; unsteady flow; vibrations of fluids.	Mr. Clayton.
EM 610. Engineering Mechanics Seminar	1-1
Reports, discussions, and preparation of papers.	Graduate Staff.

DEPARTMENT OF ENTOMOLOGY

Graduate Faculty

Professors: CLYDE F. SMITH, Head, WALTER M. KULASH, T. B. MITCHELL.
Professor Emeritus: B. B. FULTON.

Associate Professors: CHARLES H. BRETT, FRANK E. GUTHRIE, WALTER
JOSEPH MISTRIC, ROBERT L. RABB, DAVID A. YOUNG, JR.

Assistant Professors: WILLIAM V. CAMPBELL, MAURICE H. FARRIER, ROBERT
T. GAST, WILLIAM A. STEPHEN.

The Master of Science and Doctor of Philosophy degrees are offered in entomology. The work in entomology is well supported by strong departments in chemistry, statistics, and the plant and animal sciences. Excellent facilities for advanced study and research are provided in the modern building designed for the use of the biological sciences. Equipment includes modern greenhouses, air conditioned laboratories with precision temperature and humidity control, spray chambers, dust towers and low temperature rooms. Facilities are provided to support research in insect toxicology, physiology, biology, ecology, and taxonomy.

The collections of adult and immature insects plus the library facilities provide opportunities for unlimited work in insect taxonomy. Teaching personnel has been so selected that well-trained individuals are available to teach the specialized courses in the various phases of advanced entomological work.

Opportunities for employment of well-trained entomologists are plentiful and varied. Research and teaching opportunities exist in many state institutions. Federal agencies offer many positions in control, research, and regulatory work. Private industry is using more and more entomologists in the development, production, control testing and sale of agricultural chemicals. Other opportunities in entomology as consultants in domestic or foreign service as well as in private business and sales are available. Or, one can go into business for himself as a pest control operator or as an insecticide formulator.

Courses for Graduates and Advanced Undergraduates

- ENT 501-502. Insect Morphology** 3-3
Prerequisite: ENT 301 or 312.
Covers general morphology, external and internal, of the insects and their relatives. Ent. 501 will deal primarily with external morphology and Ent. 502 with internal morphology. (Given on odd years). Mr. Young.
- ENT 511. Systematic Entomology** 3-0
Prerequisite: ENT 301 or 312.
A somewhat detailed survey of the orders and families of insects, designed to acquaint the student with these groups and develop in the student some ability in the use of keys, descriptions, etc. (Given on odd years.) Mr. Young.
- ENT 522. Entomological Technique** 0-3
Prerequisite: ENT 301 or 312.
A laboratory course designed to acquaint the student with the various methods and techniques commonly employed in entomology, including a brief instruction in drawing and the photographic process. (Given on even years). Mr. Young.
- ENT 531. Insect Ecology and Behavior** 3-0
Prerequisite: ENT 301 or 312 or equivalent.
The influence of environmental factors on insect development, distribution and behavior. (Given on even years.) Mr. Rabb.
- ENT 541, 542. Immature Insects** 4-2
Prerequisite: ENT 301 or 312 or equivalent.
541 is a study of the characteristics of the immature forms of the orders and principal families of insects. 542 is a detailed study of the immature forms of some special group of insects of the students' own choosing. (Given on even years.) Mr. Rabb.
- ENT 551, 552. Applied Entomology** 3-3
Prerequisite: ENT 301 or 312
An advanced course in which the principles of applied entomology are studied in respect to the major economic insect pests. Methods of determining and examining insect damage, the economic importance of insects, and the chief economic pests of man, food, and fiber are studied as well as laws and regulations pertaining to insects and insecticides. (Given on odd years.) Mr. Kulash.
- ENT 561. Literature and History of Entomology** 3-0
Prerequisite: ENT 301 or 312 or equivalent.
A general course intended to acquaint the student with literature problems of the scientist, mechanics of the library and book classification, bibliographies of the zoological sciences, abstract journals, forms of bibliographies, forms of literature, preparation of scientific paper; taxonomic indexes and literature (with a historical background) and history of the development of zoological science from ancient to modern times with emphasis on entomology. (Given on odd years.) Mr. Farrier.

ENT 571. Forest Entomology 3-0

Prerequisite: ENT 301 or 312.

A study of methods of identification of forest pests, the factors governing their abundance, habits, and control. (Given on even years.)

Mr. Kulash.

ENT 582. Medical and Veterinary Entomology 0-3

Prerequisite: ENT 301 or ENT 312.

A study of the morphology, biology and control of the parasitic arthropods of man, domestic and wild animals. (Given on odd years.)

Mr. Harkema.

ENT 590. Special Problems Credits by arrangement

Prerequisites: Graduate Standing and Consent of the Instructor.

Original research on special problems in entomology not related to a thesis problem, but designed to provide experience and training in research.

Graduate Staff.

ENT 592. Acarology 0-3

Prerequisite: ENT 312.

A systematic survey of the mites and ticks with emphasis on identification, biology and control of the more common and economic forms attacking material, plants and animals including man. (Given on even years.)

Mr. Farrier.

Courses for Graduates Only

ENT 601, 602. Principles of Taxonomy 3-3

Prerequisite: ENT 511.

A course introducing the methods and tools used in animal taxonomy, designed to promote a better understanding of taxonomic literature, and provide a foundation for taxonomic research. (Given on even years.)

Mr. Young.

ENT 611. Insect Physiology 4-0

Prerequisite: ENT 312, ENT 502, CH 451, or equivalent.

The course deals with the aspects of animal physiology related to insects. The functions of the various insect organs are discussed and how these systems are disrupted by economic poisons. Laboratory work includes the use of standard physiological apparatus with emphasis on methods rather than obtaining results. (Given on odd years.)

Mr. Gast.

ENT 621. Insect Toxicology 4-0

Prerequisite: ENT 312, CH 426 or equivalent.

The course deals with chemical and physical characteristics of insecticides and formulations and their effects on biological systems. Modes of action and mammalian toxicities are also discussed. Laboratory work involves insect culture work, formulating insecticides and evaluating the effectiveness of various materials. (Given on even years.)

Mr. Gast.

ENT 632. Advanced Systematic Entomology 0-3

Prerequisite: ENT 511.

A detailed study of some special insect group of the student's own choosing.
Mr. Young.

ENT 680. Seminar

1-1

Prerequisite: Graduate standing in Entomology or closely allied fields.

Discussion of entomological topics selected and assigned by Seminar Chairman.
Graduate Staff.

ENT 690. Research

Credits by arrangement

Prerequisite: Graduate standing in Entomology or closely allied fields.

Original research in connection with thesis problem in entomology.

Graduate Staff.

DEPARTMENT OF FIELD CROPS

Professors: PAUL HENRY HARVEY, Head, DAN ULRICH GERSTEL, WALTON CARLYLE GREGORY, KENNETH R. KELLER, GLENN CHARLES KLINGMAN, ROY LEE LOVVORN, THURSTON J. MANN, GORDON KENNEDY MIDDLETON, PHILIP ARTHUR MILLER, ROBERT PARKER MOORE.

Associate Professors: CHARLES A. BRIM, DOUGLAS SCALES CHAMBLEE, LUTHER SHAW, GUY LANGSTON JONES, DONALD LORAIN THOMPSON.

Assistant Professors: IRVING T. CARLSON, WILL A. COPE, JOHN W. DUDLEY, DONALD A. EMERY, HARRY DOUGLASS GROSS, JOSHUA A. LEE, JACK R. MAUNEY, DONALD EDWIN MORELAND, LYLE L. PHILLIPS, ROBERT P. UPCHURCH.

The Department of Field Crops offers training leading to the degrees of Master of Science and Doctor of Philosophy in the following fields: Plant Breeding, Crop Production, Forage Crop Ecology, and Weed Control.

Facilities—The Department of Field Crops is housed in Williams Hall which provides excellent facilities for graduate training. In addition to the office and laboratory space assigned each student, numerous other facilities are available for use in carrying on a program of graduate study. These include special preparation rooms for soil and plant samples, cold storage facilities for plant material, air conditioned rooms for studying physical properties of the cotton fiber and of the tobacco leaf, and soil and plant analytical service laboratories. Greenhouses situated at the rear of Williams Hall are provided with benches, tables, ground beds, lights and other necessary equipment. A total of 16 farms are owned or operated by the State for research investigations. These farms are located throughout the State to include a wide variety of soil and climatic conditions needed for experiments in plant breeding and crop management.

Supporting Departments—Strong supporting departments greatly increase the graduate students' opportunities for a broad and thorough training. Included among those departments in which graduate students in Field Crops work cooperatively or obtain instructions are Botany, Chemistry, Genetics, Mathematics, Plant Pathology, Soils, and Statistics.

Opportunities—In North Carolina, a state which derives 80 per cent of its agricultural income from farm crops, the opportunities for the well trained agronomist are exceedingly great. The recipients of advanced degrees in Field Crops at North Carolina State College are found in positions

of leadership in research and education throughout the nation and the world where, through their technological training, they continue to contribute to the betterment of agriculture.

Courses for Advanced Undergraduates

FC 412. Advanced Pastures and Forage Crops

0-2

Prerequisite: FC 312.

Pasture species and management (cultural treatment) from an international viewpoint, and the inter-relationship of grazing animals on pasture development and management will be emphasized. Natural grassland areas and the place of special plant species will be considered.

Mr. Gross.

FC 413. Plant Breeding

0-3

Prerequisite: GN 411.

The application of genetic principles to the improvement of economic plants, including discussions of the methods employed in the development and the perpetuation of desirable cones, varieties, and hybrids.

Mr. Harvey.

FC 414. Weeds and Their Control.

Prerequisite: CH 203 or equivalent.

Principles involved in cultural and chemical weed control. Discussions on chemistry of herbicides and the effects of the chemicals on the plant. Identification of common weeds and their seeds is given.

Mr. Klingman.

Courses for Advanced Undergraduates and Graduates

FC 511. Tobacco Technology

2-0

Prerequisite: FC 311, BO 421 or equivalent.

A study of special problems concerned with the tobacco crop. The latest research problems and findings dealing with this important cash crop will be discussed.

Mr. Jones.

FC 521. Special Problems

Credits by arrangement

Prerequisite: Admitted only with consent of instructor.

Special problems in various phases of Field Crops. Problems may be selected or will be assigned. Emphasis will be placed on review of recent and current research.

Graduate Staff.

FC 541 (GN 541 or HRT 541). Plant Breeding Methods

3-0

Prerequisites: GR 512; recommended ST 511.

An advanced study of methods of plant breeding as related to principles and concepts of inheritance.

Messrs. Mann, Haynes.

FC 542. (GN 542 or HRT 542) Plant Breeding Field Procedures

2 in Summer Sessions

Prerequisites: FC 541 or GN 541 or HRT 541.

Laboratory and field study of the application of the various plant breeding techniques and methods used in the improvement of economic plants.

Messrs. Haynes, Mann.

Courses for Graduates Only*

FC 611. Forage Crop Ecology

0-2

Prerequisites: FC 412; BO 441.

A study of the effect of environmental factors on the growth of forage crops. Attention will be given to methods of research in forage ecology.

Mr. Chamblee.

* Students are expected to consult the instructor before registration.

FC 612. Special Topics in Weed Control

0-2

Prerequisites or Corequisites: FC 414, BO 403, BO 532 or 533.

Detailed examination of current concepts and literature of weed control. The chemistry, physiology, ecology, taxonomy, microbiology, equipment, and techniques used in weed control research will be discussed.

Graduate Staff.

FC 631. Seminar

1-1

Prerequisites: Graduate standing.

Scientific articles, progress reports in research, and special problems of interest to agronomists reviewed and discussed.

A maximum of two credits is allowed towards the Master's degree, but any number towards the Doctorate.

Graduate Staff.

FC 641. Research

Credits by arrangement

Prerequisites: Graduate standing.

A maximum of six credits is allowed towards the master's degree, but any number towards the doctorate.

Graduate Staff.

THE SCHOOL OF FORESTRY

Professors: RICHARD JOSEPH PRESTON, Dean, JAMES SAMUEL BETHEL, ROY MERWIN CARTER, CLARENCE EARL LIBBY, T. EWALD MAKI, BRUCE J. ZOBEL.

Associate Professors: CLARENCE ARTHUR HART, WILLIAM DYKSTRA MILLER, THOMAS O. PERRY, ALFRED J. STAMM.

Graduate work in forestry is offered through the Graduate School to meet the needs of two classes of students:

1. The professional degree of Master of Forestry or Master of Wood Technology is designed for students desiring a broad knowledge of the several branches of forestry with emphasis upon advanced professional specialization.

2. The degree of Master of Science is designed for students desiring to enter fields of research or teaching. This degree requires a sound fundamental background in scientific courses and a carefully designed program of scientific research. A reading knowledge of one modern foreign language is required.

3. The degree of Doctor of Philosophy is offered in several fields of forestry.

Candidates for the Master's degree will fall under one of the following categories:

1. Students with a bachelor's degree in forestry from a school of recognized standing. These students may secure the master's degree in one academic year.

2. Students with a bachelor's degree, other than in forestry, from a college, university, or scientific school of high standing. These students may secure the master's degree in two academic years provided they have the requirements in botany, chemistry, and mathematics required in the freshman and sophomore years of the curricula. Candidates for the degree

Master of Forestry or Master of Science in Forestry who do not hold an undergraduate degree in forestry must start their program with the summer camp.

3. Students not possessing a bachelor's degree may earn, through proper selection of courses, a Bachelor of Science degree in one of the forestry curricula at the end of the fourth year and a Master's degree in Forestry or Wood Technology at the end of the fifth year.

A wide and rapidly expanding field of employment possibilities is available in the Southeast to young men trained in forestry. Until recent years most job opportunities were with government agencies in managing our public forests, and this still constitutes a major source of employment. These agencies include state and federal forest services, extension services, and other groups such as the Soil Conservation Service and the Tennessee Valley Authority.

In recent years job opportunities with private industries have expanded greatly. Increasing numbers of technically trained young men are entering a wide variety of professional positions in the fields of forest land management, watershed management, logging, sawmilling, veneer and plywood manufacturing, pulp and papermaking, kiln drying, wood preservation, plastics and other chemical derivatives of wood, and the manufacture of wood products such as furniture, dimension stock, and various prefabricated items.

Graduate training offers tangible well-established values to young men of proven ability. The demand for men with advanced degrees in forestry has far exceeded the supply for many years.

Graduate preparation is essential for the corps of specialists which are needed in many fields. Training through the Master's degree is almost a requirement for men entering college teaching and public or industrial research. State and federal agencies as well as forest industries are employing research investigators at unprecedented levels.

The continuing rapid expansion of southern forestry has resulted in a corresponding expansion in the need for trained men. As a general rule most employers will prefer a candidate with graduate training. While forest industry and public forest administration does not normally require graduate training, increasing numbers of positions in these fields are being filled by men with advanced forestry degrees, particularly the Master's degree, and a man with the Master's degree has a distinct advantage over one without it.

Kilgore Hall houses the administrative offices of the School of Forestry. The first floor houses portions of the Wood Products Laboratory and the second and third floors consist of laboratories, library, classrooms and offices. The Reuben B. Robertson Pulp and Paper Laboratory provides 12,000 square feet of space for teaching and research in the production of pulp and paper. The Brandon P. Hodges Wood Products Laboratory provides 18,000 square feet of space for pilot plant installations for product development work in the manufacture of lumber, veneer, plywood, particle board, laminated structures, furniture and other fabricated wood products.

The School of Forestry now owns, or has access to, over 90,000 acres of forest land located in six tracts and representing major forest types in the

state. The largest tract is the Hofmann Forest on the coastal plain which is operated by the North Carolina Forestry Foundation for the benefit of the School of Forestry. The Hill Forest in Durham County, the Hope Valley Forest in Chatham County, the Goodwin Forest in Moore County, and the Schenck Memorial Forest in Wake County include representative types of the Piedmont area. The Wayah Recreational Area of the North Carolina National Forest near Franklin is located in a typical mountain forest, and facilities at this area, leased from the Government, supplement the previously established forestry camps of the Hofmann and Hill Forests and provide the School with permanent, well-equipped, modern camps in each of the three major regions of the State.

An extensive research program in the fields of wood products, genetics and management, sponsored by the Agricultural Experiment Station, the U. S. Forest Service, and the lumber, plywood, furniture, pulp and paper, and particle board industries provides broad opportunities for graduate research at the Master's and doctoral level. These programs provide research assistantships for graduate students whose backgrounds qualify them. Much valuable equipment is made available by industry for research in wood technology and it is accessible to the graduate student working in this area.

Courses for Advanced Undergraduates

- FOR 401. Wood Preservation** 0-2
Factors causing wood deterioration; preservative materials and treatments; wood by-products from mill and forest waste. Mr. Carter.
- FOR 402. Foundation of Forest Management** 2-0
Prerequisites: FOR 274 or FOR 311.
The integration of silviculture, forest measurements and economics in the management of woodland area. (Not open to students majoring in forest management). Mr. Bryant.
- FOR 403. Paper Technology Laboratory** 0-3
Development of various types of paper finishes with particular attention to stock preparation, sizing, filling and coloring. The finished products are tested physically and chemically and evaluated from the standpoint of quality and in comparison with the commercial products they are intended to duplicate. Mr. Hitchings.
- FOR 404. Management Plans** 0-3
Senior Camp
Application of management, logging, silvicultural and utilization practices on assigned areas. Each student must make a forest survey of an individual area and submit a report. Staff.
- FOR 405. Forest Inventory** 0-2
Senior Camp.
Practical field work in timber estimating and compilation of field data. Mr. Bryant.
- FOR 406. Forest Industries** 0-2
Senior Camp
A field study of logging, milling and manufacturing with reports based on inspection trips. Staff.
- FOR 407. Field Silviculture** 0-2
Senior Camp
Prerequisite: FOR 361.
Studies of forest communities; dendrology of the coastal section of North Carolina; silviculture practices. Mr. Miller.
- FOR 411, 412. Pulp and Paper Mill Equipment** 3-2
Principles of operations, construction and design of process equipment employed in the pulp and paper industry. Mr. Cook.
- FOR 413. Paper Testing Laboratory** 2-0
Physical, chemical and microscopical examination of experimental and commercial papers and evaluation of the results in terms of the utility of the products tested. Mr. Hitchings.

- FOR 422. Forest Products** 3-0
Prerequisites: FOR 201, CH 203 or 426.
The source and method of obtaining derived and manufactured forest products other than lumber. Mr. Carter.
- FOR 423. Logging and Milling** 3-0
Timber harvesting and transportation methods, equipment and costs; safety and supervision; manufacturing methods with regular and shortlog types of sawmills. Mr. Barefoot.
- FOR 432. Merchandising Forestry Products** 2-0
Principles and practices in the distribution and marketing of the products obtained from wood; organization and operation of retail, concentration and wholesale outlets. Mr. Carter.
- FOR 434. Wood Operations I.** 3-0
Prerequisites: FOR 301, 302, EC 450 or 455.
Organization of manufacturing plants producing wood products including company organization, plant layout, production planning and control. Analysis of typical manufacturing operations in terms of processes, equipment, size and product specification. The organization and operation of Wood Products markets. Merchandising practices and procedures. Mr. Thomas.
- FOR 435. Wood Operations II.** 0-3
Prerequisites: FOR 301, 302, EC 450 or 455, MA 202 or 212.
The application of the techniques of operations analysis to management decision making in the wood products field. Choice of products to manufacture. Allocation of production resources. Determining upon an inventory policy. Development of product distribution system. The elements of statistical quality control. Mr. Thomas.
- FOR 441. Mechanical Properties of Wood** 3-0
Prerequisites: FOR 201, 303.
Strength and related properties of commercial woods; standard A.S.T.M. strength tests; toughness; timber fastenings; design of columns; simple, laminated and box beams; trusses and arches. Mr. Thomas.
- FOR 451. Paper Coloring Laboratory** 2-0
Evaluation and identification of dyestuffs and the development of color formulas for dyeing pulp and paper. Mr. Libby.
- FOR 452. Forest Grazing** 2-0
Management of range areas, all grazing regions with special consideration of the south-east. Mr. Bryant.
- FOR 461. Paper Converting** 1-0
A survey of the principal processes by which paper and paper board are fabricated into the utilitarian products of everyday use. Mr. Libby.
- FOR 462. Artificial Forestation** 0-2
Production, collection, extraction, and storage of forest tree seeds; nursery practice; field methods of planting. Mr. Perry.
- FOR 463. Plant Inspection** 0-1
One week inspection trips covering representative manufacturers of pulp and paper and papermaking equipment. Mr. Libby.
- FOR 471. Pulp Technology Laboratory** 4-0
Preparation and evaluation of the several types of wood pulp. The influence of the various pulping and bleaching variables on pulp quality are studied experimentally and these data evaluated critically. Mr. Libby.
- FOR 472. Forest Policy and Administration** 2-0
Civil timber law, illustrated by court cases; state and federal forest policy; job-load analysis in national forest administration. Mr. Miller.
- FOR 481. Pulping Processes and Products** 2-0
Prerequisites: FOR 201, CH 203 or 426.
Fiber manufacturing processes and equipment; wall, insulation and container board products; manufacture of roofing felts; pulp products manufacturing; resin treated and specialty products, lignin and wood sugar products.
- FOR 482. Pulp and Paper Mill Management** 0-2
A survey of the economics of the pulp and paper industry is followed by a study of the work of the several departments of a paper mill organization and the functions of the executives who administer them. Mr. Cook.
- FOR 491, 492. Senior Problems.** 1 to 4
Staff

Courses for Graduates and Advanced Undergraduates

- FOR 501. Forest Valuation** 3-0
 Prerequisite: FOR 372.
 The theory and techniques of valuation of forest land, timber stands, and forest practices as investments and for appraisals of damages. Risks and hazards in forestry as they apply to forest investments, forest insurance and forest taxation. Mr. Bryant.
- FOR 511. Silviculture** 3-0
 Prerequisites: FOR 361, BO 421.
 The principles and application of intermediate and reproductive methods of cutting; controlled burning, silvicides, and other methods of hardwood control. The application of silvicultural methods in the forests of the United States. Mr. Miller.
- FOR 512. Forest Economics** 3-0
 Prerequisites: FOR 372, EC 201.
 Economics and social value of forests; supply of, and demand for, forest products; land use; forestry as a private and public enterprise; economics of the forest industries. Mr. Bryant.
- FOR 513. Tropical Woods** 0-2
 Prerequisite: FOR 203.
 Structure, identification, properties, characteristics and use of tropical woods, especially those used in plywood and furniture. Mr. Bethel.
- FOR 521, 522. Chemistry of Wood and Wood Products** 3-3
 Prerequisites: FOR 201 or 202; CH 203, 215; PY 212.
 Fundamental chemistry and physics of wood and wood components; pulping principles; electrical and thermal properties. Mr. Stamm.
- FOR 531, 532. Forest Management** 3-3
 Prerequisite: FOR 372.
 Management of timber lands for economic returns; the normal forest taken as the ideal; the application of regulation methods to the forest. Mr. Bryant.
- FOR 533. Advanced Wood Structure and Identification** 2-0
 Prerequisite: FOR 202.
 Advanced microscopic identification of the commercial woods of the United States and some tropical woods; microscopic anatomical features and laboratory techniques. Mr. Hart.
- FOR 553. Forest Photogrammetry** 0-2
 Prerequisite: FOR 372.
 Corequisite: FOR 531.
 Interpretation of aerial photographs, determination of density of timber stands and area mapping. Mr. Bryant.
- FOR 573. Methods of Research in Forestry** Credits Arranged
 Prerequisite: Senior or graduate standing.
 Research procedures, problem outlines, presentation of results; consider-



FORESTRY

KILGORE HALL

Kilgore Hall
Forestry



Weighing wasps fed radioisotopes.



Field studies in cotton genetics.

ation of selected studies by forest research organizations; sample plot technique. Messrs. Bethel, Maki, Zobel.

FOR 591. Forestry Problems Credits Arranged
Prerequisite: Senior or graduate standing.
Assigned or selected problems in the field of silviculture, logging, lumber manufacturing, pulp technology, or forest management. Graduate Staff.

Courses for Graduates Only

FOR 601. Advanced Forest Management Problems Credits Arranged
Prerequisite: Graduate standing.
Directed studies in forest management. Graduate Staff.

FOR 603. Technology of Wood Adhesives 0-3
Prerequisites: CH 425, 426; FOR 433.
The fundamentals of adhesion as applied to wood to wood, and wood to metal bonding. Technology of adhesives. Preparation and use of organic adhesives. Testing of adhesives and evaluation of quality of adhesives and bonded joints. Mr. Bethel.

FOR 604. Timber Physics 3-0
Prerequisite: FOR 441.
Density, specific gravity and moisture content variations affecting physical properties; physics of drying at high and low temperatures; thermal, sound, light and electrical properties of wood. Mr. Bethel.

FOR 605. Design and Control of Wood Processes 0-3
Prerequisite: FOR 604.
Design and control equipment for processing wood. Mr. Bethel.

FOR 606. Wood Process Analysis 3-0
Prerequisites: FOR 512, 604.
Analysis of wood processes through the solution of comprehensive problems involving the physics of temperature and moisture relations. Mr. Bethel.

FOR 607. Advanced Quality Control 0-3
Prerequisites: FOR 606, ST 515.
Advanced statistical quality control as applied to wood processing. Mr. Bethel.

FOR 611. Forest Genetics 3 or 3
Prerequisites: GN 411 and permission of instructor.
Application of genetic principles to silviculture, management and pulp utilization. Emphasis is on variations in wild populations, on the bases for selection of desirable qualities and on fundamentals of controlled breeding. Mr. Zobel.

FOR 621. Advanced Wood Technology Problems Credits Arranged
Prerequisite: Graduate Standing.
Selected research in wood technology problems of an advanced nature. Graduate Staff.

FOR 671. Problems in Research

Credits Arranged

Prerequisite: Graduate Standing.

Specific forestry problems that will furnish material for a thesis.

Graduate Staff.

FOR 681. Graduate Seminar

Prerequisite: Graduate standing in Forestry or closely allied fields.

Presentation and discussion of progress reports on research, special problems, and outstanding publications in forestry and related fields.

Graduate Staff.

DEPARTMENT OF GENETICS

Graduate Faculty

Professors: HAROLD FRANK ROBINSON, Head; CAREY HOYT BOSTIAN, DANIEL SWARTWOOD GROSH, BENJAMIN WARFIELD SMITH, STANLEY GEORGE STEPHENS.

Assistant Professors: THERESE MARIE KELLEHER, KEN-ICHI KOJIMA, DALE FREDERICK MATZINGER, LAWRENCE EUGENE METTLER, ROBERT HARRY MOLL.

Associate Members of the Genetics Faculty

Professors: FRED DERWARD COCHRAN, COLUMBUS CLARK COCKERHAM, DAN ULRICH GERSTEL, EDWARD WALKER GLAZENER, WALTON CARLYLE GREGORY, PAUL HENRY HARVEY, FRANK LLOYD HAYNES, TEDDY THEODORE HEBERT, GUY LANGSTON JONES, KENNETH RAYMOND KELLER, JAMES EDWARD LEGATES, THURSTON JEFFERSON MANN, GORDON KENNEDY MIDDLETON, PHILIP ARTHUR MILLER, ELMER LEON MOORE, HAMILTON ARLO STEWART, CARLOS FROST WILLIAMS, BRUCE JOHN ZOBEL.

Associate Professors: JAY LAWRENCE APPLE, ERNEST OSCAR BEAL, CHARLES ALOYSIUS BRIM, RICHARD ROBERT NELSON, THOMAS E. PERRY, DANIEL TOWNSEND POPE, DONALD LORAIN THOMPSON, NASH NICKS WINSTEAD.

Assistant Professors: WILLIAM LOWRY BLOW, IRVING THEODORE CARLSON, EMMETT URCEY DILLARD, RICHARD GWYN, JAMES WALKER HARDIN, LYLE LLEWELLYN PHILLIPS.

Graduate study under direction of the Genetics Faculty may enable the student to qualify for the Master of Science or the Doctor of Philosophy degree. A candidate for the Master's degree must acquire a thorough understanding of genetics and its relation to other biological disciplines and must present a thesis based upon his own research. In addition to a comprehensive knowledge of his field, a candidate for the doctorate must demonstrate his capacity for independent investigation and scholarship in genetics.

At North Carolina State College there are no sharp divisions along departmental lines between theoretical and applied aspects of genetic research. The members and associate members of the Genetics Faculty are located in nine different departments of the School of Agriculture and the School of Forestry. They are studying an extremely wide range of genetic problems and are utilizing not only the "classic" laboratory material

(*Drosophila*, *Habrobracon*, mice) but also farm animals and agricultural and horticultural plants of the region. A student has therefore a wide choice of research problems in any of the following fields: cytology and cytogenetics, physiological and irradiation genetics, forest genetics, population genetics, and the application of quantitative genetics to breeding methodology.

The offices and laboratories of the department are located in Gardner Hall with greenhouse facilities adjacent to the building. A genetics garden for use in the intensive research with plants and teaching functions is located three miles from the departmental offices. The departmental staff and the associate faculty members in Animal Industry, Field Crops, Horticulture, Poultry Science, Plant Pathology, Experimental Statistics, and Forestry are most fortunate in being able to draw upon the extensive facilities of the North Carolina Agricultural Experiment Station.

Courses for Advanced Undergraduates

GN 411. The Principles of Genetics

3 or 3

Prerequisites: BO 103 or ZO 103.

An introductory course. The physical basis of inheritance; genes as units of heredity and development; qualitative and quantitative aspects of genetic variation. Mr. Bostian.

Courses for Graduates and Advanced Undergraduates

GN 503. (See AI 503. Genetic Improvement of Livestock.)

GN 512. Genetics

4-0

Prerequisite: GN 411.

Intended for students desiring more thorough and detailed training in fundamental genetics with some attention to physiological aspects. (Students conduct individual laboratory problems). Mr. Grosch.

GN 513. Cytogenetics I

4-0

Prerequisite: GN 512 (or with consent of instructor).

The chromosomes as vehicles of heredity. Mitosis and meiosis as bases of genetic stability and recombination. Structural and numerical aberrations and their effect upon the breeding systems of plants and animals. Inter-specific hybrids and polyploids. Lectures and laboratory. Mr. Gerstel.

GN 520. (See PO 520. Poultry Breeding.)

**GN 532. (See ZO 532. Biological Effects of Radiation).

GN 540. Evolution

3-0

Prerequisite: GN 411.

The facts and theories of evolution in plants and animals. The causes and consequences of organic diversity. Mr. Smith.

GN 541. Plant Breeding Methods

3-0

Prerequisites: GN 512 and either ST 511 or consent of instructor.

Principles and methods of plant breeding. Messrs. Mann, Haynes.

GN 542. (See FC 542 or HRT 542. Plant Breeding Field Procedures.)

**Given 1961-62 and alternate years.

Courses for Graduates Only

- GN 601. (See PO 601. Advanced Poultry Breeding.)
- GN 602. (See AI 602. Population Genetics in Animal Improvement.)
- *GN 607 & PP 607. Genetics of Fungi 3-0
Prerequisite: GN 512 or equivalent and consent of instructor.
Review of major contributions in fungus genetics with emphasis on principles and theories that have evolved in recent developments.
Mr. Nelson.
- GN 611. (See FOR 611. Forest Genetics.)
- **GN 614. Cytogenetics II 0-3
Prerequisites: Gn 513 or graduate standing in botany or zoology.
Laboratory and discussion: the cytogenetic analysis of natural and experimental material, plant and animal. Assigned exercises and student projects. The course provides the student with a working knowledge of cytogenetic procedure.
Mr. Smith.
- GN 620. Genetic Concepts of Speciation 3-0
Prerequisites: GN 512 and either GN 513 or GN 540.
Review of current ideas on the mechanisms of the origin of species and the nature of species differentiation.
Mr. Stephens.
- **GN 621. Genetics of Populations 0-3
Prerequisite: GN 512; Recommended: GN 540.
Review of the forces molding the genetic structure of natural and artificial populations of plants and animals.
Mr. Mettler.
- GN 626. (See ST 626. Statistical Concepts in Genetics.)
- GN 633. Physiological Genetics 0-3
Prerequisite: GN 512.
Recent advances in physiological genetics. Attention will be directed to literature on the nature and action of genes, and to the interaction of heredity and environment in the expression of the characteristics of organisms.
Mr. Grosch.
- GN 641, 642. Colloquium in Genetics 2-2
Prerequisites: Graduate standing, consent of instructor.
Informal group discussion of prepared topics assigned by instructor.
Graduate Staff.
- GN 651. Seminar 1-1
Prerequisite: Graduate standing.
- GN 661. Research Credits by Arrangement
Original research related to the student's thesis problem.
A maximum of six credits for the Master's degree; by arrangement for the Doctorate.
Graduate Staff.

*Given 1960-61 and alternate years.

**Given 1961-62 and alternate years.

GN 671. Special Problems in Genetics

1 to 3-1 to 3

Prerequisites: Advanced graduate standing and consent of instructor.

Special topics designed for additional experience and research training.
Graduate staff.

GEOLOGICAL ENGINEERING

See Department of Mineral Industries

DEPARTMENT OF HISTORY AND POLITICAL SCIENCE

Graduate Faculty

Professors: PRESTON EDSALL, Head; MARVIN L. BROWN, JR., STUART NOBLIN.
Associate Professor: ABRAHAM HOLTZMAN.

Assistant Professors: BURTON F. BEERS, WILLIAM J. BLOCK, LADISLAS F. REITZER.

No graduate degrees are offered in history or political science at State College. Graduate programs leading to advanced degrees in this field are offered at the University of North Carolina at Chapel Hill. The courses listed below are eligible for graduate credit when they form a part of an approved graduate program in other departments, and work in history and political science may serve as a minor field.

Courses for Advanced Undergraduates

HI 401. Russian History 3-0

This course presents the major trends in Russian social, political, economic, and cultural history, with emphasis on the nineteenth and twentieth centuries. USSR policy is studied in relation to the full sweep of Russian history.

HI 402. Asia and the West 0-3

A history of Asia from the mid-nineteenth century to the present with emphasis on Asian nationalism and conflict with the imperial powers.

HI 415. International Relations since 1870 0-3

A study of the relations between the major countries of the world since 1870. In addition to the history of actual diplomatic relations, crises, and settlements, attention is given to the causes of the various international crises. The course also includes study of the development of international organizations and the various points of conflict between international law and organization and the sovereignty of independent governments.

HI 422. History of Science 3-0

A study of the evolution of science from antiquity to the present with particular attention given to the impact of scientific thought upon selected aspects of western civilization. The course provides a broad perspective of scientific progress and shows the interrelationship of science and major historical developments.

HI, PS, EC, 461. The Soviet Union 0-3

An analysis of the structure and function of the major Soviet economic, political, and social institutions with special stress on the historical roots and continuity of Russian civilization. The course is presented in three equal phases of approximately five weeks each, covering Russian history, Soviet government, and Soviet economy.

PS 401. American Parties and Pressure Groups 3 or 3

After a brief survey of those features of American government essential to an understanding of the political process, the course proceeds to examine the American electorate and public opinion and devotes its major attention to the nature, organization, and programs of pressure groups and political parties and to their efforts to direct opinion, gain control of government, and shape public policy. Special attention is given to party organization and pressure group activity at the governmental level and to recent proposals to improve the political party as an instrument of responsible government.

PS 406. Problems in North Carolina Government. 0-2

Prerequisite: PS 201 or an acceptable substitute.
Selected problems arising from the operation of the legislative, administrative, and judicial machinery in North Carolina. In addition to acquiring a comprehensive view of these problems each student will make an intensive study of a special phase of one of them.

Courses for Graduates and Advanced Undergraduates

- HI 534. (RS 534). Farmers' Movements** 0-3
Prerequisite: 3 credits in American history, American government, sociology or a related social science.
A history of agricultural organizations and movements in the United States and Canada principally since 1865, emphasizing the Grange, the Farmers' Alliance, the Populist revolt, the Farmers' Union, the Farm Bureau, the Equity societies, the Nonpartisan League, cooperative marketing, government programs, and present problems. Mr. Noblin.
- PS 501. Modern Political Theory** 3-0
Prerequisite: PS 201 or HI 205 or an acceptable substitute.
A study of the state and its relationship to individuals and groups, approached through the reading of selected passages from the works of outstanding political philosophers from the sixteenth century to the present. Mr. Holtzman.
- PS 502. Public Administration** 0-3
Prerequisite: PS 201 or PS 202 or an acceptable substitute.
A study of the principles and problems of governmental administration. Topics include the characteristics of public management at all levels; the relationship of administration and the establishment of governmental policies; the principles of management and the organizational arrangements of today's highly specialized governmental units; the role of leadership and its processes; the problems and techniques of communication, coordination, and public relations; the management of personnel and finances; and the problems of securing administrative responsibility in a democratic society. The course also uses the case studies in public policy and administration which have been published by the Inter-University Case Program. Mr. Block.
- PS 503. International Organization** 2-0
Prerequisite: PS 201 or HI 205 or an acceptable substitute.
A study of the evolving machinery and techniques of international organization in the present century with particular emphasis on recent developments. The actual operation of international organization will be illustrated by the study of selected current international problems. Graduate Staff.
- PS 510 (EC 510) Public Finance** 0-3
Prerequisite: The basic course in Economics required by the degree-granting school.
A survey of the theories and practices of government taxing, spending, and borrowing, including inter-governmental relationships and administrative practices and problems. Mr. Block.
- PS 512. American Constitutional Theory** 0-3
Prerequisite: PS 201 or an acceptable substitute.
Basic constitutional doctrines, including fundamental law, judicial review, individual rights and political privileges, and national and state power. Special attention is given to the application of these doctrines to the

regulation of business, agriculture, and labor and to the rights safeguarded by the First, Fifth, and Fourteenth Amendments to the Constitution.

Mr. Edsall.

Course for Graduates Only

PS 620. Problems in Political Science

3-0

Prerequisite: Advanced graduate standing.

An independent advanced research course in selected problems of government and politics. The problems will be chosen in accordance with the needs and desires of the students registered for the course.

Graduate Staff.

DEPARTMENT OF HORTICULTURE

Graduate Faculty

Professors: FRED DERWARD COCHRAN, Head; JOHN LINCOLN ETCHELLS, MONROE EVANS GARDNER, JOHN BERNARD GARTNER, FRANK LLOYD HAYNES, JR., JOHN MITCHELL JENKINS, JR., IVAN DUNLAVY JONES, CARLOS FROST WILLIAMS.

Associate Professors: MAURICE WILBUR HOOVER, CLARENCE LESLIE MC-COMBS, DANIEL TOWNSEND POPE, DAVID RUDGER WALKER.

Assistant Professors: WALTER ELMER BALLINGER, CONRAD HENRY MILLER, ROBERT JOHNSON SCHRAMM, JR.

The Department of Horticulture offers the Master of Science degree and the professional degree, Master of Horticulture. The requirements for each of these degrees are outlined in an earlier section of this catalog. Evidence of high scholastic achievement in the basic biological sciences is particularly desirable for students who expect to study for the Master of Science degree in Horticulture.

The department now has excellent physical facilities for training students in Horticulture. The building, completed in 1953, houses Horticulture and Forestry. It contains adequate office, classroom, and laboratory space and the equipment necessary for a well rounded graduate program. A greenhouse range is available which contains ten separate 24' x 30' compartments especially designed for research. This range and others make available for research and teaching approximately 25,000 sq. ft. of glass. A modern and well equipped processing laboratory is located on the first floor of the building with adjoining analytical laboratories. This provides facilities for research and teaching in the preservation of foods by quick-freezing, canning and other methods. Cold storage compartments in the building make possible extensive investigations dealing with the storage and handling of fruits, vegetables, and ornamentals. The department has six analytical laboratories and a cytological laboratory. Out-field research problems are conducted on the student laboratory farm at Raleigh and at ten of the research stations located in the various geographical sections of the State.

The opportunities for employment after advanced training are many and varied: teaching and research in state and privately endowed educational

institutions; research positions with U.S.D.A., both foreign and domestic; extension specialists and county agents; research and promotional work with food, chemical, and seed concerns; orchard, nursery and greenhouse supervisors; food technologists and inspectors.

Courses for Advanced Undergraduates

- HRT 421. Fruit Production** 3-0
 Prerequisite: SOI 200 (or concurrently)
 Methods of production of the principal tree and small fruits. This is designed to give an understanding of the practices involved in fruit production. Messrs. Correll and Walker.
- HRT 432. Vegetable Production** 3-3
 Prerequisite: SOI 200 (or concurrently)
 Soil preparation, seedage, plant production, fertilization, irrigation and general culture of vegetable crops. Messrs. Miller and McCombs.
- **HRT 441. Commercial Floriculture** 3-0
 Prerequisite: SOI 200 (or concurrently)
 Greenhouse construction, heating and management. Mr. Randall.
- **HRT 442. Commercial Floriculture** 0-3
 Prerequisite: HRT 441.
 Botanical characters, importance, propagation, culture and preparation for market of the floral crops commonly grown in the greenhouse. Mr. Randall.
- HRT 451. Principles of Fruit and Vegetable Processing** 3-0
 Principles and methods involved in the preservation of fruits and vegetables, with emphasis placed on canning and freezing. Mr. Jones.
- HRT 462. Grading and Inspection of Processed Fruits and Vegetables** 0-2
 Prerequisite: Registration by permission of the instructor.
 Methods of inspection, grading and critical appraisal for quality of the principal fruit and vegetable produces. Mr. Hoover.
- HRT 481. Breeding of Horticultural Plants**
 Prerequisite: GN 411.
 The application of genetics and plant breeding to the improvement of horticultural crops. Messrs. Galletta and Henderson.

Courses for Graduates and Advanced Undergraduates

- HRT 501. Horticultural Problems** Credits by arrangement
 Prerequisites: BO 421 or GN 411 and permission of instructor
 Investigation of a problem in horticulture, each student selecting a problem and conducting the investigations under the direction of the instructor. The problem may last one or two semesters. Credits will be determined by the nature of the problem, not to exceed a total of 4 hours. Graduate Staff.
- **HRT 512. Handling and Storage of Ornamental Plants** 0-3
 Prerequisite: BO 421.
 A study of the handling and storage of ornamental plants and plant parts. Consideration will be given to the chemical and physiological changes occurring in storage, storage facilities, materials and methods for handling and storing these products. Mr. Gartner.
- HRT 521, 522. Technology of Fruit and Vegetable Products** 3-3
 Prerequisite: BO 312 (or concurrently).
 Comprehensive treatment of principals and methods of preservation of fruits and vegetables, including small scale plant operation and commercial processing plant visits. Mr. Jones.

****Offered 1960-61 and in alternate years.**

- *HRT 532. Advanced Fruit Production** 0-4
 Prerequisites: HRT 421, BO 421 (or concurrently)
 A comprehensive study of principles involved in production of tree and small fruits. Mr. Walker.
- HRT 541. Plant Breeding Methods**
 See GN 541
- *HRT 562. Handling and Storage of Fruits and Vegetables** 0-3
 Prerequisite: BO 421.
 The chemical and physiological changes occurring during handling and storage of fruits and vegetables. Consideration will also be given to facilities for handling and storage. Mr. McCombs.
- **HRT 571. Advanced Vegetable Crops** 3-0
 Prerequisites: BO 421 (or concurrently) and consent of instructor.
 A study of the origin, distribution, botanical relationships, and basic principles of production of the major vegetable crops. Mr. Cochran.
- HRT 581. Senior Seminar** 1-1
 Prerequisite: Senior in Horticulture
 Presentation of scientific articles, progress reports in research, and special problems in horticulture and related fields. Mr. Gardner.

Courses for Graduates Only

- HRT 601. Advanced Olericulture** 3-0
 Prerequisite: HRT 571.
 A study of a specific technical problem, involving original investigations, including a survey of pertinent literature, or an exhaustive study of literature on a given subject or plant. Mr. Cochran.
- HRT 602. Advanced Ornamental Horticulture** 0-3
 Prerequisite: BO 421, HRT 422.
 A study of specific problems in ornamental crops, either through a study of pertinent literature or by an original investigation. Mr. Gartner.
- HRT 612. Advanced Fruit and Vegetable Processing** 0-3
 Prerequisite: HRT 522 or equivalent.
 Critical study of certain processing methods as applied to fruit and vegetable preservation. Mr. Jones.
- **HRT 621. Methods and Evaluation of Horticultural Research** 3-0
 Prerequisite: BO 421, ST 511 (or concurrently).
 Methods and techniques in the field of horticulture and their application in the solution of current problems. Critical evaluation of published papers reporting results of horticultural experiments. Methods of compiling data and presenting results. Mr. Cochran.
- HRT 632. Advanced Pomology** 0-3
 Prerequisite: HRT 532.

*Offered 1961-62 and in alternate years.

**Offered 1960-61 and in alternate years.

A critical study of specific problems in fruit crops including current literature. Mr. Walker.

HRT 641. Research

Credits by arrangement

Prerequisite: Graduate standing in Horticulture—consent of instructor.

Original research on specific problems in fruits, vegetables, or ornamental crops, or in fruit and vegetable processing. Thesis prepared should be worthy of publication.

A maximum of six credits is allowed toward the Master of Science degree; no limitation on credits in Doctorate program.

Graduate Staff.

HRT 651. Seminar

1-1

Prerequisite: Graduate standing in Horticulture.

Presentation of scientific articles, progress reports in research, and special problems in Horticulture and related fields. Presentation of one or more papers each semester is required.

Graduate Staff.

**DEPARTMENT OF INDUSTRIAL ARTS
AND
DEPARTMENT OF INDUSTRIAL EDUCATION
See Education**

DEPARTMENT OF INDUSTRIAL ENGINEERING

Graduate Faculty:

Professors: CLIFTON A. ANDERSON, Head, ROBERT GORDON CARSON, JR.,
ERNEST SIGURD JOHNSON.

Associate Professor: ROBERT W. LLEWELLYN.

Visiting Lecturers: JOHN S. LITTLE, RUDOLPH WILLARD.

Industrial Engineering is a relatively new branch of engineering that combines a knowledge of how industry is organized and operated with a basic training in the fundamentals of engineering. Graduate study leading to the Master of Science degree in Industrial Engineering is offered in the department. The rapid development of industry in North Carolina in recent years has opened many opportunities for men trained in plant operation and management.

Courses for Advanced Undergraduates

IE 401. Industrial Engineering Analysis

3-0

Prerequisite: IE 304, MA 401, MA 405, ST 362.

An introductory course in some of the more recently developed operations research techniques; applications of analysis of variance, multiple correlation and other statistical methods, queuing theory, linear programming; graphical methods of solutions; information theory and servomechanisms in Industrial Engineering. A balance will be sought between theory and practical applications.

IE 402. Industrial Engineering Analysis

0-3

Prerequisite: IE 401.

Continuation of IE 401.

- IE 408. Production Control** 3-0
 Planning, scheduling and dispatching of production in manufacturing operations; conversion of sales requirements into production orders; construction of production budgets and their relation to labor, materials and machines; laboratory project involving the development and operation of the production control system of a typical plant.
- IE 425. Sales and Distribution Methods** 0-2
 An analysis of the distribution of industrial and consumer products; the effect of increased productivity on sales and distribution channels; development and marketing of new products; merchandising and packaging. Sales training and sales engineering programs.
- IE 430. Job Evaluation and Wage Incentives** 0-3
 Job analysis, classification and specification. Grading, ranking, factor comparison and point systems of job evaluation in determining equitable rates for job content. Wages surveys and merit rating. Utilization of time standards in design, installation and operation of financial incentive plans. Comparison of various wage and salary plans. Effect of wage payment methods on industrial relations practices.
- IE 443. Quality Control** 3-0
 Economic balance between cost of quality and value of quality, and techniques for accomplishing this balance. Organization for, specification and utilization of quality controls. Statistical theory and analyses as applied to sampling, control charts, tolerance determination, acceptance procedures and control of production.

Courses for Graduates and Advanced Undergraduates

- IE 515. Process Engineering** 3-0
 Prerequisites: IE 401, 443.
 The technical process of translating product design into a manufacturing program. The application of industrial engineering in the layout, tooling, methods, standards, costs and control functions of manufacturing. Laboratory problems covering producer and consumer products.
 Mr. Little.
- IE 517. Automatic Processes** 3-0
 Prerequisites: IE 401, 443.
 Principles and methods for automatic processing. The design of product, process, and controls. Economic, physical, and sociological effects of automation.
 Messrs. Anderson and Johnson.
- IE 521. Control Systems and Data Processing** 3-0
 Prerequisites: IE 401.
 This course is designed to train the student in the problem and techniques required for systematic control of the production process and the business enterprise. This includes training in the determination of control factors, the collection and recording of data, and the processing, evaluation and use of data. The course will illustrate the applications and use of data processing equipment and information machines in industrial processes. Case problems will be used extensively.
 Mr. Llewellyn.
- IE 531. Quantitative Job Evaluation Methods** 0-3
 Prerequisite: IE 401.
 A study of statistical and mathematical methods of testing and designing job evaluation plans. Ranking, contingency, and analysis of variance methods of testing plans and rating performance. Multiple regression and linear programming methods of designing plans.
 Mr. Llewellyn.
- IE 543. Standard Data** 3-0
 Prerequisites: ST 361 or ST 515, one course in motion and time study.
 Theory and practice in developing standard data from stopwatch

observations and predetermined time data; methods of calculating standards from data; application of standard data in cost control, production planning and scheduling, and wage incentives. Mr. Anderson.

IE 551. Standard Costs for Manufacturing 0-3

Prerequisites: One course in accounting and one course in motion and time study.

The development, application and use of standard costs as a management tool; use of industrial engineering techniques in establishing standard costs for labor, material and overhead. Analysis of variances and setting of budgets. Measures of management performance. Mr. Willard.

IE 581. Project Work 2 to 6-2 to 6

Investigation and report on an assigned problem for students enrolled in the fifth-year curriculum in Industrial Engineering. Graduate Staff.

Courses For Graduates Only

IE 621. Inventory Control Methods 3-0

Prerequisites: IE 402, IE 521, MA 511.

A study of inventory policy with respect to reorder sizes, minimum points and production schedules. Simple inventory models, models with restrictions, price breaks, price changes, analysis of slow-moving inventories. Introduction to the smoothing problem in continuous manufacturing. Applications of linear and dynamic programming and zero-sum game theory.

Mr. Llewellyn.

IE 651. Special Studies in Industrial Engineering Credits by Arrangement

Prerequisite: Graduate standing.

The purpose of this course is to allow individual students or small groups of students to take on studies of special areas in Industrial Engineering which fit into their particular program and which may not be covered by existing industrial engineering graduate level courses. The work would be directed by a qualified staff member who had particular interest in the area covered by the problem. Such problems may require individual research and initiative in the application of industrial engineering training to new areas or fields. Graduate Staff.

IE 671. Seminar 1-1

Seminar discussion of industrial engineering problems for graduate students. Case analyses and reports. Mr. Anderson.

IE 691. Industrial Engineering Research Credits by arrangement

Graduate research in Industrial Engineering for thesis credit.

Graduate Staff.

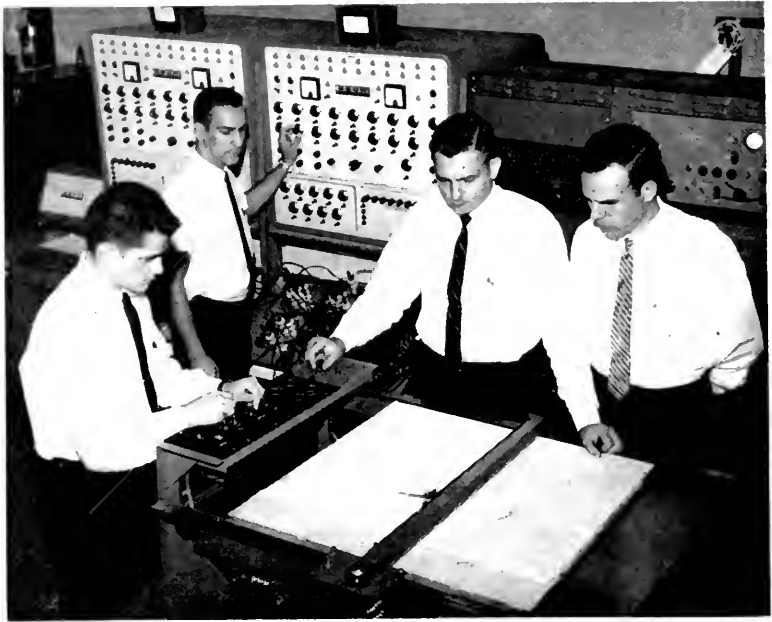
DEPARTMENT OF MATHEMATICS

Graduate Faculty

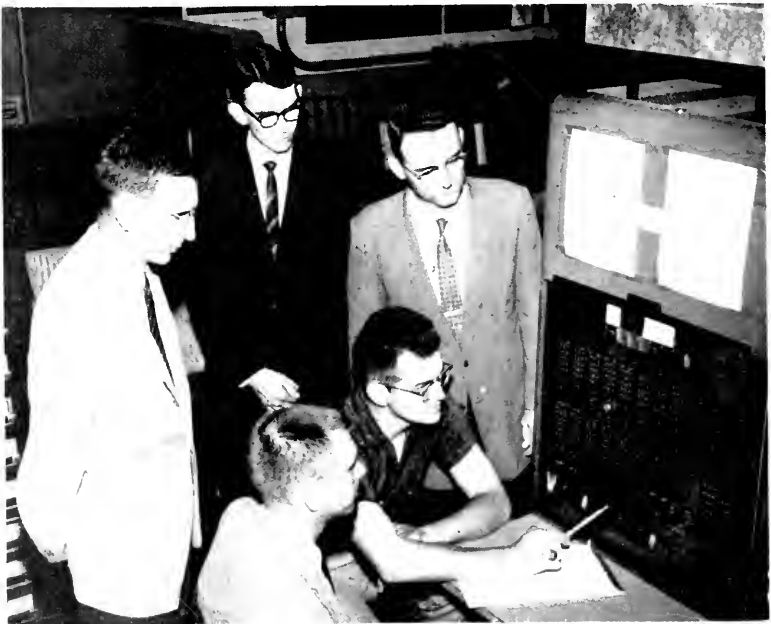
Professors: JOHN WESLEY CELL, Head, ROBERTS COZART BULLOCK, JOHN MONTGOMERY CLARKSON, WALTER JOEL HARRINGTON, JACK LEVINE, CAREY GARDNER MUMFORD, HOWARD M. NAHIKIAN, HUBERT VERN PARK, LOWELL SHERIDAN WINTON.



Riddick Laboratories
Industrial Engineering



Graduate students in Applied Mathematics operating the GEDA Analog Computer.



Graduate students and staff in Applied Mathematics at the IBM 650 Digital Computer.

Associate Professors: GEORGE CHARLES CALDWELL, CHARLES J. STANDISH,
RAIMOND ALDRICH STRUBLE.

The Department of Mathematics offers a graduate program leading to the Master of Science degree in applied mathematics. A knowledge of advanced mathematics has become increasingly essential for graduate study in all of the disciplines offered in any technological branch of a university. This is particularly true in the several fields of engineering, physics, statistics and the biological sciences; and is becoming increasingly so in economics and psychology.

Mathematicians are in great demand (and short supply) as college teachers, as members of mathematics groups working with large electronic computers, and as members of research teams in industrial or government laboratories. The demands of an expanding industry in North Carolina and especially of the Research Triangle will necessitate the employment of many mathematicians in this state.

Courses for Advanced Undergraduates

- MA 403. Fundamental Concepts of Algebra** 3-0
Prerequisites: MA 202 or MA 212.
Integers; integral domains; rational numbers; fields, rings, groups; vectors and vector spaces; linear transformation; matrices. Boolean algebra.
- MA 404. Fundamental Concepts of Geometry** 3-0
Prerequisite: MA 202 or MA 212.
Foundation of geometry; laws of logic; affine geometry; geometric transformations; homogeneous coordinates; comparison of Euclidean and non-Euclidean geometry.
- MA 405. Introduction to Determinants and Matrices** 3 or 3
Prerequisite: MA 202 or MA 212.
Properties of determinants; theorems of Laplace and Jacobi; systems of linear equations. Elementary operations with matrices; inverse, rank, characteristic roots and eigenvectors. Introduction to algebraic forms.
- MA 411. Introduction to Applied Mathematics** 3 or 3
Prerequisite: MA 301.
Infinite series, introduction to Fourier series, special functions defined by integrals, line and multiple integrals, partial differentiation, and a brief treatment of vector analysis.

Courses for Graduates and Advanced Undergraduates

- MA 501. Numerical Analysis I** 3 or 3
Prerequisite: MA 301
Numerical solution of equations, introduction to theory of random errors, least squares and curve fitting, finite-difference tables and the theory of interpolation, numerical integration, numerical differentiation, and elements of difference calculus. Some methods will be presented for use in hand calculations and others for digital computer solution.
Graduate Staff.
- MA 502. Numerical Analysis II** 0-3
Prerequisites: MA 501, MA 511
Summation of series, numerical solution of ordinary differential equations, solution of systems of linear equations, and numerical solution of partial differential equations. Presentation of sources of error in numerical computation and brief analyses will be included in the various numerical procedures.
Graduate Staff.

- MA 511. Advanced Calculus I** 3 or 3
 Prerequisite: MA 301 and B-average in Mathematics.
 This two-semester sequence, MA 511 and MA 512, is intended as foundation mathematics for graduate study in Engineering, Physics, or Applied Mathematics.
 Number system, sequences, limits, continuity; derivatives, differentials. Functions of several variables, limits and continuity, partial differentiation, Jacobians; directional derivatives. Riemann integral, multiple integrals, Green's theorem. Graduate Staff.
- MA 512. Advanced Calculus II** 3 or 3
 Prerequisite: MA 511.
 Line integrals and applications. Infinite series, review of convergence tests, uniform convergence, powers series and applications. Fourier series. Improper integrals. Graduate Staff.
- MA 514. Boundary Value Problems** 3-0
 Co-requisite: MA 512.
 Ordinary homogeneous and non-homogeneous differential equations with boundary values; elements of partial differential equations; applications of Fourier series and other methods to the solutions of certain boundary value problems in partial differential equations; harmonic functions. Mr. Mumford.
- MA 521. Advanced Geometry** 3-0
 Prerequisites: MA 202, MA 405.
 Coordinates in space; direction angles and cosines; planes, lines, points; matrices; surfaces and curves; quadric surfaces; transformation; analysis of general equation of degree 2; matrix algebra and its applications; introduction to algebraic geometry. Messrs. Clarkson and Nahikian.
- MA 522. Theory of Probability** 0-3
 Prerequisite: MA 301.
 Definitions, discrete and continuous sample spaces, combinatorial analysis, Stirling's formula, simple occupancy and ordering problems, conditional probability, repeated trials, compound experiments, Bayes' theorem, binomial, Poisson and normal distributions, the probability integral, random variables, expectation. Messrs. Clarkson and Levine.
- MA 532. Differential Equations II** 0-3
 Prerequisite: MA 301 and "B" average in mathematics.
 Solution of second order linear equations with variable coefficients; exact equations; Green's functions; singular points and series solutions; Bessel functions, Legendre polynomials, and other special functions defined by ordinary differential equations; approximate methods; introduction to partial differential equations. Graduate Staff.
- MA 533. History of Mathematics** 0-3
 Prerequisite: MA 202 or MA 212.
 Evolution of the number system; trends in the development of modern mathematics; lives and contributions of outstanding mathematicians. Mr. Nolstad.

MA 535. An Introduction to Computers. 3 or 3

Prerequisite: MA 301 and either 405 or one 500 level course.

The elements of number systems and commonly used machine codes; fundamental coding and programming techniques for the IBM 650. Selected problems are subjected to numerical and error analysis and solved on the IBM 650. The elements of the theory and applications of the analog computer, solutions of certain differential systems on the Donner analog computer.
Messrs. Caldwell and Wilson.

MA 541. Vector Analysis 3 or 3

Prerequisite: MA 301 and either 405 or one 500-level course.

The algebra of vectors and dyadics; elementary space geometry in vector form; scalar and vector differentiation of scalar, vector and dyadic functions; curvilinear coordinates; line, surface, and volume integrals; integral transformations; applications.
Graduate Staff.

MA 543. Elementary Complex Variable Theory 0-3

Prerequisite: MA 511 or MA 532.

Operations with complex numbers; derivatives, analytic functions, integrals, definitions and properties of elementary functions, multiple-value functions, power series, residue theory and applications, conformal mapping.
Messrs. Bullock, Mumford, Winton.

Courses for Graduates Only

MA 602. Partial Differential Equations 0-3

Prerequisite: MA 512.

Partial differentiation, functional dependence, envelopes, eliminants, Lagrange's equation, general and complete integrals, non-linear equations of first and higher orders; Fourier series with applications to problems in vibrations, heat and fluid flow, electricity; boundary value problems.
Mr. Mumford.

MA 605. Non-linear Differential Equations 3-0

Prerequisites: MA 512, MA 532.

Non-linear differential equations associated with important physical systems; contrasts with linear system; use of phase plane diagrams and other geometrical methods of analysis, approximate solutions by perturbation, Fourier series, slow variations of amplitude and phase, linearized equations, and computer methods; study of limit cycles and stability.
Mr. Struble.

MA 611. Complex Variable Theory and Applications I 3-0

Prerequisite: MA 512.

Elementary functions; analytic functions and Cauchy-Riemann equations; conformal mapping and applications; Taylor and Laurent series; contour integration and residue theory; the Schwarz-Christoffel transformation.
Messrs. Bullock and Mumford.

MA 612. Complex Variable Theory and Applications II 0-3

Prerequisite: MA 611.

Conformal mapping and applications to flow phenomena; multiple-valued functions and Riemann surfaces; further applications of residue theory;

analytic continuation; infinite series and asymptotic expansions; elliptic functions and other special functions in the complex domain; structure of functions. Mr. Bullock.

MA 615. Theory of Functions of a Real Variable I Alternate Years
Prerequisite: MA 512. 3-0

Sets and spaces; continuity and differentiability of real functions.
Messrs. Harrington and Struble.

MA 616. Theory of Functions of a Real Variable II Alternate Years
Prerequisite: MA 615. 0-3

Measure, measurable sets and functions, theory of Lebesgue integration.
Messrs. Harrington and Struble.

MA 621. Introduction to Modern Abstract Algebra 3-0
Prerequisite: MA 512.

A study of the abstract structure and properties of groups, rings and ideals, and fields. Messrs. Nahikian and Park.

MA 622. Vector Spaces and Matrices 0-3
Prerequisite: MA 511.

Introduction to matrices; vector spaces; equivalence, rank, inverse of matrices; determinants; congruence; quadratic forms; polynomials over a field; similarity; characteristic roots. Messrs. Nahikian and Park.

MA 625. Introduction to Differential Geometry Alternate
Prerequisite: MA 512. Summers 3

Theory of curves and surfaces in 3-dimensional Euclidean space with special reference to those properties invariant under the rigid body motions. Messrs. Levine and Winton.

MA 632. Operational Mathematics I 3-0
Corequisite: MA 543 or MA 611.

Laplace transform with theory and application to problems in ordinary and partial differential equations arising from engineering and physics problems; Fourier integral and Fourier transforms and applications. Mr. Cell.

MA 633. Operational Mathematics II 0-3
Prerequisite: MA 632.

Extended development of the Laplace and Fourier transforms and their uses in the solution of problems in ordinary and partial differential equations and in difference equations; Sturm-Liouville systems; advanced theory in ordinary and partial differential equations; other infinite and finite transforms and their applications. Mr. Cell.

MA 635. Mathematics of Computers 0-3
Prerequisites: MA 502, MA 512, 535.

Corequisite: MA 405 or MA 622.

The development of methods for the solution of selected problems involving matrices; integral rational equations; ordinary and partial differential equations. Particular attention is paid to the question of convergence and stability; examples solved on the IBM 650. Mr. Caldwell.

MA 641. Calculus of Variations Alternate Summers 3

Prerequisite: MA 512

The simplest problem of the calculus of variations in detail; variable endpoints; iso-perimetric problems; Hamilton's principle; least action principle; introduction to the theory of linear integral equations of the Volterra and Fredholm types. Mr. Winton.

MA 651. Expansion of Functions Alternate Summers 3

Prerequisites: MA 611, 633 or equivalent.

Expansion of functions of one or more variables in Taylor series; asymptotic series, infinite products, partial fractions, continued fractions, series of orthogonal functions; applications in ordinary partial differential equations, difference equations and integral equations.

Messrs. Cell and Harrington.

MA 661. Tensor Analysis I 3-0

Prerequisites: MA 512, 541.

Recommended (but not required) MA 521, 602, 622.

The basic theory; tensor algebra, tensor calculus; invariant theory; quadratic differential forms; covariant differentiation, curvature tensor; geometric applications, Riemannian spaces, parallelism, geodesics, normal coordinates; generalized vector analysis; physical applications: dynamics, Lagrange's equations, generalized coordinates; the geometry of dynamics; kinematic and action line elements, holonomic and non-holonomic systems; configuration space, dynamics in n-dimensions. Mr. Levine.

MA 662. Tensor Analysis II 0-3

Prerequisite: MA 661.

Continuation of physical applications. Elasticity: finite strains, equations of compatibility, strain invariants, stress tensor, equations of motion, generalized Hooke's law, isotropic stress-strain relations; hydrodynamics: perfect fluids, viscous fluid, viscosity tensor, equations of motion; electromagnetic theory: Maxwell's equations, plane waves, stress-energy tensor. Mr. Levine.

MA 681. Special Topics in Analysis 3-3

MA 683. Special Topics in Algebra 3-3

MA 685. Special Topics in Numerical Analysis 3-3

MA 687. Special Topics in Geometry 3-3

MA 689. Special Topics in Applied Mathematics 3-3

The above courses, MA 681-MA 689, afford opportunities for graduate students to study advanced topics in mathematics under the direction of members of the graduate staff. These will on occasion consist of one of several areas such as, for example, Advanced Theory of Partial Differential Equations, Topology, Mathematics of Plasticity or of Viscoelasticity, Mathematics of Orbital Mechanics.

MA 691. Research in Mathematics Credits by arrangement

Prerequisite: Graduate standing and approval of adviser.

Individual research in the field of Mathematics.

DEPARTMENT OF MECHANICAL ENGINEERING

Graduate Faculty

Professors: JOHN FRANCIS LEE, Head, PATRICK HILL McDONALD, JR., Graduate Administrator, NORVAL WHITE CONNER, JESSE SEYMOUR DOOLITTLE, KARL P. HANSON, THOMAS F. IRVINE, JR., RICHARD BENNETT KNIGHT, ROBERT MCLEAN PINKERTON, ROBERT BARTON RICE*, JAMES WOODBURN.

Associate Professors: GENNARO L. GOGLIA, EDGAR LEE HARRISBERGER, JOHN KERR WHITFIELD.

Assistant Professors: THOMAS BENSON LEDBETTER, WILLIAM THOMAS SNYDER.

Instructor: HUSEYIN C. TOPAKOGLU.

The Master of Science degree is offered in Mechanical Engineering. Entrance to the various programs in the Department is normally based upon an accredited baccalaureate degree in engineering. In addition, the general admission requirements of the Graduate School must be fulfilled.

At present, the major emphases in graduate study are the thermal sciences, including classical thermodynamics, heat transfer and transport phenomena, statistical thermodynamics; gas dynamics (aerothermochemistry, aerothermodynamics) and the mechanical sciences, such as principles of fluid motion, dynamics of compressible flow and viscous fluids, vibrations, mechanical transients, stress analysis, and applied mechanics; the aero and space sciences of aerodynamics, propulsion, and aeroelasticity.

The professional technological interests of the Department are represented by graduate courses in nuclear power plants, steam and gas turbines, refrigeration, internal combustion engines, lubrication, mechanics of machinery, and machine design analysis and synthesis.

Graduate programs in Mechanical Engineering normally include substantial work in the basic sciences of mathematics and physics, and study in related engineering departments is encouraged.

The fundamental objective of graduate study in this field is to prepare the student for leadership in the various categories of research, teaching and design. To this end, the graduate student is placed in intimate contact and association with the graduate faculty who conduct individual research. Participation in a research project as a research assistant or employment as a teaching assistant is regarded as significant experience during residence.

Prospective graduate students are invited to correspond with the Department and receive a more complete description of the faculty, its activities, and the facilities available; or preferably, to visit Broughton Hall and experience first-hand the stimulus of energetic pursuit of learning in this community.

A program of graduate studies leading to the doctorate has been submitted for administrative approval. Inquiries are invited.

* On leave.

Courses for Advanced Undergraduates

- ME 401. Power Plants** 3 or 3
 Prerequisite: ME 302.
 Required of seniors in Mechanical Engineering.
 Application of thermodynamics, economics and other basic studies to the engineering of power generation, with emphasis on energy balances, combustion, steam generation, prime movers, heat transfer devices and auxiliaries.
- ME 405. Mech. Engineering Laboratory III** 1-0
 Prerequisite: ME 306.
 Required of seniors in Mechanical Engineering.
 The selection of appropriate instrumentation and the experimental analysis of small, predetermined engineering systems designed for flexibility and wide variation of parameters. Systems cover the gamut of Mechanical Engineering activity with emphasis on analysis of system rather than characteristics of particular systems.
- ME 406. Mech. Engineering Laboratory IV** 0-1
 Prerequisite: ME 405.
 Required of seniors in Mechanical Engineering.
 Individual or small group investigation of an original problem under the supervision of a faculty member with an interest in the problem area. The investigation may be experimental, analytical, or both. Emphasis is placed on the philosophy and methodology of engineering research, and on individual thinking and effort.
- ME 410. Jet Propulsion**
 Prerequisites: ME 302 and ME 352 or EM 430.
 Application of fundamental principles of thermodynamics and the mechanics of a compressible fluid to the processes of jet-propulsion and turbo-propeller aircraft; the effect of performance of components on performance of engine; analysis of engine performance parameters.
- ME 411. Machine Design I** 3-0
 Prerequisites: ME 312, EM 321.
 Required of seniors in Mechanical Engineering.
 Basic principles of the mechanical sciences applied to the analysis of machines, devices, and mechanical systems. State of stress, state of strain, elasticity, working stresses, stress concentration, fatigue, impact and shock, plasticity, thermal stress, wear, lubrication and contact stress.
- ME 412. Machine Design II** 0-3
 Prerequisite: ME 411.
 Required of seniors in Mechanical Engineering.
 Synthesis of machines, devices, and mechanical systems. The specification of systems, formulation of region of design, synthesis of elements, complete analysis of the ensemble, evaluation and closure of the design. Project activity with research emphasis.
- ME 441, 442. Technical Seminar** 1-1
 Prerequisite: Junior or senior standing.
 Meetings once a week for the delivery and discussion of student papers on topics of current interest in Mechanical Engineering.
- ME 453. Applied Aerodynamics** 3-0
 Prerequisite: ME 352.
 Determination of design data, tunnel wall and ground effect interference corrections, spanwise and chordwise load distributions, performance estimation, and stability and control analysis. Attention is given to transonic and supersonic aerodynamics.
- ME 455, 456. Aeronautical Laboratory I, II** 1-1
 Prerequisite: ME 352.
 Demonstration of wind tunnel testing methods and principles of fluid motion. Aerodynamic tests of airplane components and complete models. Calibration of instruments and other laboratory exercises related to aeronautical engineering.
- ME 459. Aircraft Structures** 3-0
 Prerequisites: ME 351, EM 321.
 Theory of aircraft structures, design principles and methods of stress analysis, emphasis on thin-walled structures.
- ME 461, 462. Airplane Design I, II** 3-3
 Prerequisite: EM 321.
 Co-requisite: ME 453.
 Design procedure, preliminary layout from design specifications, weight and balance, performance estimation, control and stability analysis, principles of stress analysis.
- ME 473. Refrigeration** 3-0
 Prerequisite: ME 372.
 Required of seniors in Heating and Air Conditioning.
 The fundamental principles of refrigeration, the performance of refrigerating machines and their application to air conditioning; controls of such systems.

ME 475, 476. Air Conditioning Laboratory III, IV

Concurrent with ME 481, 482.

Required of seniors in Heating and Air Conditioning.

The testing of heat transfer equipment including feed water heaters, radiators, convectors, unit heaters, heating panels; heating boilers, hot air furnaces, stokers, oil burners; air conditioners of both the spray and coil types, evaporative condensers.

ME 481, 482. Air Conditioning Design I, II

3-3

Required of seniors in Heating and Air Conditioning.

The design, layout and cost estimates of various types of heating and air conditioning systems.

Courses for Graduates and Advanced Undergraduates

ME 501. Steam and Gas Turbines

3 or 3

Prerequisites: ME 302 and ME 352 or EM 430.

Fundamental analysis of the theory and design of turbomachinery flow passages; control and performance of turbomachinery; gas-turbine engine processes.

Mr. Doolittle.

ME 502. Heat Transfer

3 or 3

Prerequisite: ME 301, MA 301.

A study of the fundamental laws of heat transfer by conduction, convection and radiation; steady and unsteady state heat transfer.

Mr. Irvine.

ME 507, 508. Internal Combustion Engine Fundamentals

3-3

Prerequisite: ME 302.

The fundamentals common to internal combustion engine cycles of operation. The Otto engine: carburetion, fuel distribution, flame propagation, normal and knocking combustion, throttling, pumping, valve and spark timing, and altitude effects; the Diesel engine: injection and spray formation, fuel rating, atomization, penetration, diesel knock, combustion, pre-combustion, and scavenging, as applied to reciprocating and rotary engines.

Mr. Ledbetter.

ME 515. Experimental Stress Analysis

3 or 3

Prerequisite: ME 312.

Stresses determined experimentally by photoelasticity methods, by mechanical and electrical strain gages, by brittle coatings, etc. Effects of varying stresses.

Mr. Whitfield.

ME 516. Photoelasticity

0-3

Prerequisite: ME 515.

Two and three-dimensional photoelasticity; the stress-optic law, isochromatics, isoclinics, stress trajectories, fractional orders of interference; three dimensional techniques, oblique incidence, rotational and thickness effects; determination of principal stresses at interior points; laboratory investigations.

Mr. Whitfield.

ME 517. Lubrication

0-3

Prerequisite: EM 430.

The theory of hydrodynamic lubrication; Reynolds' equation, the Sommerfeld integration, effect of variable lubricant properties and energy equation for temperature rise. Properties of lubricants. Application to design of bearings. Boundary lubrication.

Mr. Harrisbeger.

ME 521. Aeothermodynamics

3 or 3

Prerequisites: ME 301, MA 301, EM 430.

An examination of the basic concepts of gas dynamics such as the continuum, domain of applicability of continuum, acoustic velocity, compressibility effects, and the conservation laws. Analysis of one dimensional flows such as isentropic flow, diabatic flow, flow with friction, the normal shock. An introduction to the vector formulation of multi-dimensional problems.

Mr. Snyder.

ME 545, 546. Project Work in Mechanical Engineering I, II

2-2

Individual or small group investigation of a problem stemming from a mutual student-faculty interest. Emphasis is placed on providing a situation for exploiting student curiosity.

Graduate Staff.

ME 554. Advanced Aerodynamic Theory

0-3

Prerequisite: ME 453.

Development of fundamental aerodynamic theory. Emphasis upon mathematical analysis and derivation of equations of motion, airfoil theory and comparison with experimental results. Introduction to supersonic flow theory.

Mr. Pinkerton.

ME 562. Advanced Aircraft Structures

0-3

Prerequisites: ME 459, ME 453.

Development of methods of stress analysis for aircraft structures, special problems in structural design, stiffened panels, rigid frames, indeterminate structures, general relaxation theory.

Graduate Staff.

ME 571. Air Conditioning

3-0

Prerequisite: ME 302.

A fundamental study of summer and winter air conditioning including temperature, humidity, air velocity and distribution.

Graduate Staff.

ME 572. Refrigeration

0-3

Prerequisite: ME 302.

A thermodynamic analysis of the simple, compound, centrifugal and multiple effect compression systems, the steam jet system and the absorption system of refrigeration.

Graduate Staff.

Courses for Graduates Only**ME 601. Advanced Engineering Thermodynamics I**

3-3

Prerequisites: ME 302 or ME 303, and MA 301.

First and Second Laws; theory of variable specific heats; general equations of thermodynamics; characteristic equations of state; reduced coordinates; prediction of properties of gases and vapors; chemical equilibrium; metastable states; thermodynamics of fluid flow.

Mr. Dootlittle.

ME 602. Statistical Thermodynamics

0-3

Prerequisites: ME 601, MA 511.

Fundamental principles of kinetic theory, quantum mechanics, statistical mechanics and irreversible phenomena with particular reference to

thermodynamics systems and processes. The conclusions of the classical thermodynamics are analyzed and established from the microscopic viewpoint.
Messrs. Goglia and Lee.

ME 603. Advanced Power Plants 3-0
Prerequisite: ME 401.

A critical analysis of the energy balance of thermal power plants; thermodynamic and economic evaluation of alternate schemes of development; study of recent developments in the production of power. Mr. Lee.

ME 604. Nuclear Power Plants 0-3
Prerequisites: ME 302, 502, EM 430, PY 419.

Resources of fuels, power reactors, reactor materials and properties, coolants, pumps, heat exchangers, nuclear gas turbine power plants, nuclear steam power plants, special purpose plants, the economics of nuclear power and selected topics on shielding, waste disposal and health precautions. Mr. Lee.

ME 605. Aerothermochemistry 0-3
Prerequisites: ME 601, MA 511 or equivalent.

A generalized treatment of combustion thermodynamics including derivation of thermodynamics quantities by the method of Jacobians, criteria for thermodynamic equilibrium, computation of equilibrium composition and adiabatic flame temperature. Introduction to classical chemical kinetics. Conservation equations for a reacting system, detonation and deflagration. Theories of flame propagation, flame stabilization, and turbulent combustion. Mr. Snyder.

ME 608. Advanced Heat Transfer I 3-0
Prerequisite: ME 502 or equivalent.

Fundamental aspects, from an advanced viewpoint, will be considered in the conduction of heat through solids, convective phenomena, and the measurement and prediction of appropriate physical properties. Boundary value problems arising in heat conduction will be examined and both numerical and function solution techniques developed. Internal and External boundary layer analyses will be made on a variety of representative convection situations. Mr. Irvine.

ME 609. Advanced Heat Transfer II 0-3
Prerequisite: ME 608.

Advanced topics in the nonisothermal flow of fluids through channels will be investigated for slug, laminar, transitional and turbulent conditions. The influence of mass transfer on flow and heat transfer processes will be considered. Radiation exchange processes between solid surfaces and solid surfaces and gases both stationary and moving will be discussed. Mr. Irvine.

ME 611, 612. Advanced Machine Design I, II 3-3
Prerequisite: ME 412.

Kinematics of mechanical media, the stress tensor, the tensor of strains, elasticity, plasticity, time-dependent behavior; theories of failure, working stresses; shock and steady dynamic loading, creep, stress concentration,

thermal stress, contact stresses; energy theories, finite difference and relaxation methods; hydrodynamic lubrication. Application to the design of machine frames, shafts, bearings, gears, springs, cams, etc.

Mr. McDonald.

ME 613. Mechanics of Machinery

3-0

Prerequisites: ME 312, MA 512.

Vector dynamics, d'Alembert's principle, Lagrange's equations; rigid kinematics, Euler's angles, rigid rotation, Coriolis accelerations; the inertia tensor. Application to mechanisms, gyroscopes, guidance and control systems, rotating and reciprocating devices.

Mr. McDonald.

ME 614. Mechanical Transients and Machine Vibrations

0-3

Prerequisites: ME 312 or EM 545, MA 512.

Dynamic loads in mechanical media are considered in two categories: steady vibrations and transient shock and impact. The Lagrange equations and the wave equation are employed to study internal stresses and displacements in mechanical devices which result from such loading.

Mr. McDonald.

ME 617. Plates and Shells in Mechanical Design

0-3

Prerequisites: MA 511, ME 611.

The concept of members which are thin in one dimension, that is, plates and shells, is applied to mechanical design with particular emphasis on type of loading, conditions of service, and compliance of the member to its environment.

Mr. McDonald.

ME 641. Mechanical Engineering Seminar I, II

1-1

Faculty and graduate student discussions centered around current research problems and advanced engineering theories.

Graduate Staff.

ME 645. Mechanical Engineering Research

3 to 6

Prerequisite: Graduate standing in ME and approval of advisor.

Individual research in the field of Mechanical Engineering.

Graduate Staff.

ME 651. Principles of Fluid Motion

3-0

Prerequisite: ME 453.

Co-requisite: MA 511.

Fundamental principles of fluid dynamics. Mathematical methods of analysis are emphasized. Potential flow theory development with introduction to the effects of viscosity and compressibility. Two dimensional and three dimensional phenomena are considered.

Mr. Pinkerton.

ME 652. Dynamics of Compressible Flow

0-3

Prerequisite: ME 651.

Properties of compressible fluids, equation of motion of one-dimensional motion, channel flows, shock wave theory, methods of observation, and flows at transonic speeds.

Mr. Pinkerton.

ME 653. Supersonic Aerodynamics

3-0

Prerequisite: ME 652.

Equations of motion in supersonic flow, Prandtl-Meyer turns, method of

characteristics, hodograph plane, supersonic wind tunnels, supersonic air-foil theory, and boundary layer shock interaction.

Mr. Pinkerton.

ME 654. Dynamics in Viscous Fluids

0-3

Prerequisite: ME 651.

Development of the Navier-Stokes equations and the boundary layer theory. Laminar and turbulent boundary layers in theory and experiment, flow separation, and transition.

Mr. Pinkerton.

METALLURGICAL ENGINEERING

See Department of Mineral Industries

DEPARTMENT OF MINERAL INDUSTRIES

Graduate Faculty

Professors: WILLIAM WYATT AUSTIN, Head, WILLIAM CALLUM BELL, WILLIAM WURTH KRIEGEL, JOHN MASON PARKER, III, HANS HEINRICH STADELMAIER, ROBERT FRANKLIN STOOPS.

Associate Professor: WILLIAM CULLEN HACKLER.

Assistant Professor: HENRY SEWELL BROWN.

The Department of Mineral Industries offers graduate programs leading to the degrees of Master of Science in Ceramic Engineering, Geological Engineering, and Metallurgical Engineering, and to the degree of Doctor of Philosophy in Ceramic Engineering. Certain graduate courses are also offered for the benefit of students majoring in other areas who may be interested in pursuing advanced work in the Mineral Industries fields.

Ceramic Engineering

The graduate program in Ceramic Engineering includes study and research in the following sub-divisions: electrical ceramics, glass, vitreous enamels and coatings, structural clay products, refractories, whitewares (wall tile, sanitary ware, dinnerware, etc.), and materials associated with nuclear reactor and missile programs.

The prerequisite for graduate work in ceramic engineering is a proficiency in the undergraduate courses required for the Bachelor's degree in Ceramic Engineering, or substantial equivalent.

The ceramic laboratories of the department are well equipped to carry forward researches in the areas previously mentioned. These facilities are augmented by those of the Ceramic Research Laboratories of the Department of Engineering Research. Also available are the Electron Microscope and X-Ray Diffraction Laboratories of that Department, and the Nuclear Reactors of the Physics Department.

Illustrative of the scope of graduate research in ceramics at North Carolina State College are some of the recent and current projects. These have encompassed studies of the dielectric and physical characteristics of ceramic bodies in the system BaTiO_3 , mechanical properties of single crystal sapphire, studies of the power losses in low dielectric constant ceramics, the

effect of devitrification of the glassy phase on the conductivity of ceramic insulator bodies, studies in spodumene, tremolite, talc, and nepheline syenite in multiframe vitreous bodies, diffusion of selected isotopes through ceramic and cermet bodies, high temperature load bearing characteristics of silica-clay refractories, the effect of alkali on the hygroscopicity of glass, studies of the maximum safe rate of drying structural clays, and the pozzolanic properties of shale.

Geological Engineering

The graduate program in Geological Engineering is directed to the advanced training of qualified scientists who are needed to locate and evaluate mineral resources of the State and nation. Candidates for admission to this program should hold the degree of Bachelor of Geological Engineering or a satisfactory equivalent.

The solution of professional problems in geology, as in other fields today, is requiring more quantitative data and specialized training than can be included in an undergraduate curriculum. Graduate training makes professional advancement more sure and rapid. A person with such training in geology will find employment with oil and mining companies, governmental agencies, and educational and research institutions.

North Carolina State College is on the Piedmont Plateau near the edge of the Atlantic Coastal Plain. A great variety of problems in igneous, sedimentary, and metamorphic geology are to be found within a radius of 50 miles of Raleigh.

Facilities are available for research in mineralogy, petrography, economic geology, mineral dressing, and problems relating to engineering. Excellent collections of geological literature are available at North Carolina State College, at the University at Chapel Hill, and at Duke University in Durham.

Metallurgical Engineering

The rapid expansion of the metal-working and related mineral industries in the South in recent years has brought about a sharp increase in the demand for trained leaders in these fields. There is at present intense emphasis on advanced study and research on the fundamental behavior of metals and alloys. From this work will come urgently-needed improvements in metallic materials of construction to withstand increasingly drastic service requirements—higher stresses, higher temperatures, corrosive and radioactive environments. Consequently the engineering graduate who avails himself of the opportunity for advanced study in this field will greatly enhance his usefulness as an engineer regardless of his field of specialization.

Opportunities for men with graduate training in metallurgy and metallurgical engineering are almost unlimited. Industry and Universities today need approximately four times as many metallurgists with advanced degrees as are available. It has been estimated that by 1975 the electrical, chemical, aircraft, and nuclear industries will require 50,000 research metallurgists and metallurgical engineers. The number presently available is approximately 3,000. Present ratios indicate that one-third to one-

half of the 50,000 graduates needed should have advanced training beyond the bachelor's degree. The shortage of graduates with advanced degrees is further accentuated by the need for qualified college faculty members to provide adequate instruction in metallurgical and related fields. Thus it is readily seen that there is a very real and urgent need for an intensification of emphasis at the graduate level on the training of metallurgical engineers to assume leadership in expanding the frontiers of knowledge of metals and alloys, and to provide a source of additional faculty manpower in this important area.

North Carolina State College is one of the few institutions in the South, and only institution in North Carolina, prepared to offer graduate instruction in metallurgical engineering. In addition to the advanced work in metallurgical engineering, the School of Engineering also offers an excellent program of supporting courses at the graduate level in the related field of physics chemistry, mathematics, engineering mechanics, and in mechanical, chemical, ceramic, and nuclear engineering.

Fellowships and Graduate Assistantships

Financial assistance is available to graduate students in the Department of Mineral Industries; Graduate assistantships permit half-time studies in either Ceramic Engineering, Geological Engineering, or Metallurgical Engineering, and half time to be devoted to teaching or other assigned duties. Also certain sponsored fellowships that permit full time to be devoted to graduate studies, such as the Edward Orton, Jr. Ceramic Foundation Fellowship, are available. Applications should be made to the Department.

CERAMIC ENGINEERING

Courses for Advanced Undergraduates

- MIC 413. Ceramic Process Principles II** 4-0
 Prerequisites: MIC 312 and CH 342.
 A continuation of MIC 312. Introduction to crystal chemistry and the constitution of glass. Consideration of special problems relating to glasses, glazes and equilibria with particular reference to refractories.
- MIC 414. Senior Thesis** 3-3
 One semester required of seniors in Ceramic Engineering. A second semester may be elected.
 An introduction to research. Literature search, laboratory investigation and written report in the form of a thesis. Conference and laboratory.
- MIC 415, 416. Ceramic Engineering Design** 2-2
 The methods of ceramic equipment, structure and plant design.
- MIC 420. Industrial Ceramics** 3-0
 A study of the various ceramic industries, including manufacturing techniques, labor and professional relationships, and the present and future status of the respective industries. Lectures and discussion.
- MIC 425. Seminar** 1-1
 One semester required of seniors in Ceramic Engineering. A second semester may be elected.
 Literature survey of selected topics in ceramic engineering. Oral and written reports, discussions.

Courses for Graduates and Advanced Undergraduates

- MIC 503. Ceramic Microscopy** 3 or 3
 Prerequisite: MIG 531.
 Petrographic techniques for the systematic study of ceramic materials

and products. Interpretation and representation of results. Mr. Kriegel.

MIC 505. Research and Control Methods 0-3
Prerequisite: MIC 413.

Lectures, demonstrations and experiments on instrumental methods of ceramic investigation and statistical methods of control. Mr. Hackler.

MIC 507, 508. Advanced Ceramic Experiments 3-3
Prerequisite: MIC 414 or equivalent.

Advanced studies in ceramic laboratory experimentation.

Graduate Staff.

MIC 511. Advanced Studies in Firing 3 or 3
Prerequisite: MIC 413.

Advanced studies of ceramic firing procedures with emphasis on the design, calculation and economic evaluation of kilns and furnaces.

Mr. Hackler.

MIC 522. Structural Clay Products 0-3
Prerequisite: MIC 413.

The technology of the structural clay products industries with emphasis on the latest developments in the field.

Mr. Kriegel.

MIC 527. Refractories in Service 3 or 3
Prerequisite: CH 342.

A study of the physical and chemical properties of the more important refractories in respect to their environment in industrial and laboratory furnaces.

Mr. Kriegel.

MIC 540. Glass Technology 3 or 3
Prerequisite: MIC 413.

Fundamentals of glass manufacture including compositions, properties and application of the principle types of commercial glass.

Mr. Hackler.

MIC 548. Technology of Cements 0-3
Prerequisite: MIC 413.

The technology of the Portland cement industry including manufacture, control and uses.

Mr. Kriegel.

Courses for Graduates Only

MIC 605, 606. Crystal Structures 2-2
Prerequisite: CH 342.

Basic laws of crystal structure. Relation of crystal structure to chemical and physical properties

Messrs. Hackler, Kriegel.

MIC 613. Ceramic Thermal Mineralogy 0-3
Prerequisite: MIC 605.

Applications of the principles of thermal chemical mineralogy to ceramic problems.

Mr. Stoops.

MIC 615, 616. High Temperature Technology 3-3
Prerequisite: MIC 613.

An advanced consideration of the generation of high temperatures,

furnace designs and atmosphere controls.

Theory of sintering, hot pressing and thermo-chemical properties of high-temperature materials. Mr. Stoops.

MIC 650. Ceramic Research

Credits by arrangement

An original and independent investigation in ceramic engineering. A report of such an investigation is required as a graduate thesis.

Graduate Staff.

MIC 660. Ceramic Engineering Seminar

1-1

Reports and discussion of special topics in ceramic engineering and allied fields.

Graduate Staff.

MIC 661. Special Studies in Ceramic Engineering

1 to 3 credits
per semester

Special Studies of advanced topics in ceramic engineering. Credit will vary with the topic.

Graduate Staff.

GEOLOGICAL ENGINEERING

Courses for Advanced Undergraduates

MIG 411, 412. Economic Geology

3-3

Prerequisites: MIG 120 and 330.

Required of seniors in Geological Engineering.

Mode of occurrence, association, origin, distribution, and uses of economically valuable minerals. Lectures, laboratories, and field trips.

Mr. Brown.

MIG 442. Petrology

0-3

Prerequisites: MIG 120 and 330.

Required of juniors in Geological Engineering.

Materials of the earth's crust; composition, texture, classification, megascopic identification, and alterations of the principal igneous, sedimentary, and metamorphic rocks. Lectures, laboratories, and field trips.

Mr. Parker.

MIG 452. Sedimentation and Stratigraphy

0-3

Prerequisite: MIG 442.

Required in Geological Engineering.

Sedimentary processes, products, and structures. Principles of sub-division of sedimentary terranes into natural units and the determination of their age and history. Lectures, laboratories, and field trips.

Mr. Parker.

MIG 461. Engineering Geology

3 or 3

Prerequisite: MIG 120.

Required in fifth year of Geological Engineering.

The application of geologic principles to engineering practice; analysis of geologic factors and processes affecting specific engineering projects.

Mr. Miller.

MIG 462. Geological Surveying

0-3

Prerequisites: MIG 351 and 442.

Required of seniors in Geological Engineering.

Methods of field observation and use of geologic surveying instruments in surface and underground work; representation of geologic features by maps, sections and diagrams. Lectures, laboratories, and field work.

Messrs. Parker, Miller.

Courses for Graduates and Advanced Undergraduates

MIG 510. Mineral Industry

3 or 3

Prerequisite: Senior standing in Mineral Industries.

Economics of mineral industry. Cycles of mineral production. Exhaustibility. Reserves. Valuation of mineral property. National resources; essential, critical, and strategic minerals. World distribution and production.

Mr. Parker.

- MIG 522. Petroleum Geology** 3 or 3
 Prerequisite: MIG 351 and 442.
 Required in fifth year of Geological Engineering.
 Properties, origin and modes of occurrence of petroleum and natural gas. Geologic and economic features of the principal oil and gas fields, mainly in the United States. Mr. Brown.
- MIG 531. Optical Mineralogy** 3-0
 Prerequisites: MIG 330 and PY 202.
 Required of seniors in Geological Engineering.
 Optical principles involved in the petrographic (polarizing) microscope and related instruments. Microscopic determination of minerals in thin section and in fragments. Lectures and laboratory work. Mr. Parker.
- MIG 552. Geophysics** 3 or 3
 Prerequisites: MIG 351, PY 202.
 Required in fifth year of Geological Engineering.
 Discussion of the fundamental principles underlying all geophysical methods; procedure and instruments involved in gravitational, magnetic, seismic, electrical and other methods of studying geological structures and conditions; study of applications and interpretations of results. Mr. Miller.
- MIG 571, 572. Mining and Mineral Dressing** 3-3
 Prerequisite: MIG 372.
 Required in fifth year of Geological Engineering.
 Principles of the mineral industry; mining laws, prospecting, sampling, development, drilling, blasting, handling, ventilation and safety; administration, surveying, assaying; preparation, beneficiation and marketing. Mr. Miller.
- MIG 581. Geomorphology** 3-0
 Prerequisite: MIG 442.
 Required in fifth year of Geological Engineering.
 A systematic study of land forms and their relations to processes and stages of development and adjustment to underlying structure. Lectures, map interpretations, and field trips. Mr. Brown.

Courses for Graduates Only

- MIG 611, 612. Advanced Economic Geology** 3-3
 Prerequisites: MIG 411, 412.
 Required in fifth year of Geological Engineering.
 Detailed study of the origin and occurrence of specific mineral deposits. Mr. Brown.
- MIG 632. Microscopic Determination of Opaque Minerals** 3 or 3
 Prerequisites: MIG 531.
 Identification of metallic, opaque minerals in polished sections by physical properties, etch reactions and microchemical tests. Laboratories. Mr. Brown.

MIG 642. Advanced Petrography**3 or 3**

Prerequisites: MIG 442, 531.

Application of the petrographic microscope to the systematic study of the composition and origin of rocks; emphasis on igneous and metamorphic rocks.

Mr. Parker.

MIG 681, 682. Seminar**1-1**

Prerequisite: Graduate standing.

Scientific articles, progress reports and special problems of interest to geologists and geological and mining engineers discussed.

Graduate Staff.

MIG 691. Geological Research**Credits by arrangement**

Prerequisite: Permission of the Instructor.

Lectures, reading assignments, and reports; special work in Geology to meet the needs and interests of the students.

Graduate Staff.

METALLURGICAL ENGINEERING

MIM 401, 402. Metallurgical Operations I, II**4-4**

Prerequisite: MIM 332.

A systematized treatment of the fundamental operations involved in the production and fabrication of metals and alloys. Part I deals primarily with procedures and operations employed in chemical or extractive metallurgy. Part II covers the operations of physical and mechanical metallurgy.

Metallurgical Engineering Staff.

MIM 421, 422. Metallurgy I, II**2-2**

Prerequisite: CH 102.

Required of seniors in M.E. and Ae.E.

The constitution, structure and properties of engineering ferrous and non-ferrous metals and alloys; influences of mechanical working and heat treatment; physical testing, corrosion and its prevention.

Metallurgical Engineering Staff.

MIM 423. Metallurgical Laboratory**1 or 1**

Co-requisite: MIM 421 or 422.

Laboratory work to accompany Metallurgy I, II.

Metallurgical Engineering Staff.

MIM 431, 432. Metallography I, II**3-3**

Prerequisite: MIM 332.

An intensive study of the principles and techniques for examination and correlation of the structure, constitution, and properties of metals and alloys.

Metallurgical Engineering Staff.

MIM 451, 452. Metallurgical Engineering Seminar**1-1**

Prerequisite: Senior standing in MET. E.

Reports and discussion of special topics in metallurgical engineering and related subjects.

Metallurgical Engineering Staff.

Courses for Graduates and Advanced Undergraduates

MIM 521, 522. Advanced Physical Metallurgy I, II**3-3**

Prerequisite: MIM 422.

Theories concerning behavior and control of engineering alloys, reaction rates in the solid state, and alloy influences; current heat treating practices; surface treatments; behavior of metals at high and low temperatures; special purpose alloys; powder metallurgy; review of modern equipment and methods for the study of metals.

Mr. Stadelmaier.

MIM 523, 524. Metallurgical Factors in Design**2-2**

Prerequisite: MIM 422

A study of the metallurgical factors that must be considered in using metals in design.

Mr. Austin.

- MIM 541, 542. Principles of Corrosion I, II** 3-3
 Prerequisite: MIM 422.
 The fundamentals of metallic corrosion and passivity. The electrochemical nature of corrosive attack, basic forms of corrosion, corrosion rate factors, methods of corrosion protection. Laboratory work included. Mr. Austin.
- MIM 545, 546. Advanced Metallurgical Experiments I, II** 3-3
 Prerequisite: MIM 422, or approval of instructor.
 Advanced engineering principles applied to a specific experimental project dealing with metallurgy or metallography. A seminar period is provided, and a written report is required. Graduate Staff.
- MIM 561. Advanced Structure and Properties of Materials** 3-0
 Prerequisite: MIM 422.
 A systematic treatment of the fundamental physico-chemical principles governing the constitution of both metallic and ceramic materials. Correlation of these principles with physical, mechanical and chemical properties of materials. Particular emphasis is placed upon materials of construction for nuclear reactors. Lecture and Laboratory. Graduate Staff.
- MIM 562. Materials Problems in Nuclear Engineering.** 0-3
 Prerequisite: MIM 561.
 Engineering aspects of problems involved in the selection and application of reactor materials. Specific attention is given to elevated temperature behavior, fatigue, corrosion, irradiation damage, and the fabrication and processing of these materials. Lecture and Laboratory. Graduate Staff.

Courses for Graduates Only

- MIM 651, 652. Theory and Structure of Metals** 3-3
 Prerequisite: MIM 522.
 An advanced interpretation of the development of theories of the metallic state with emphasis on modern physical concepts. Topics include theory of crystallinity, bonding forces, stability of metallic structures, diffusion, and dislocation theory. Mr. Stadlemaier.
- MIM 695. Metallurgical Engineering Research** Credits by arrangement
 Independent investigation of an appropriate problem in Metallurgical Engineering. A report on this investigation is required as a graduate thesis. Graduate Staff.

DEPARTMENT OF MODERN LANGUAGES

Graduate Faculty

Professor Emeritus: LAWRENCE EARLE HINKLE.
 Professor: GEORGE W. POLAND, Head.

The courses listed below are recommended to assist graduate students in preparing themselves for the use of modern foreign languages in research and advanced study. Students are given the opportunity of working a translation project in connection with their subject of major interest.

Although these courses do not carry graduate language credit, they may be taken as a means of attaining a reading knowledge.

Certification may be obtained in languages not normally taught by the department with special permission of the Graduate School.

ML 110, 111(G). Russian

3-3

These two courses are given for graduate students only, the first dealing with grammar and structure and the second, with reading of Russian scientific material.

ML 401, 402. Scientific French

3-3

Prerequisite: Knowledge of basic French grammar.

A study of scientific literature appearing in current bulletins, magazines and technical journals. Reading material is adjusted to individual needs. Conferences.

MI 405, 406. Scientific Spanish

3-3

Prerequisite: Knowledge of basic Spanish grammar.

A study of scientific literature appearing in current bulletins, magazines, and technical journals. Special attention given to the comprehension of the thought of the article under consideration and its accurate rendition into English. Conferences.

ML 503. German Grammar for Graduate Students

3-3

This course is open to Graduate Students only and is designed to present the grammar of scientific German as rapidly as possible in preparation for the reading course which follows.

ML 504. Scientific German

3-3

Prerequisite: ML 503 or equivalent.

Reading and translation of technical German, supplemented by discussions on terminology, word order, vocabulary analysis and other linguistic techniques. Subject material adjusted to individual needs; Conferences.

DEPARTMENT OF OCCUPATIONAL INFORMATION AND GUIDANCE

See Education

DEPARTMENT OF PHILOSOPHY AND RELIGION

PHI 401. Foundations of Science

3 or 3

Nature and validity of knowledge, basic concepts of modern science, scientific method, and the implication of the philosophy of modern science for ethics, social philosophy, and the nature of reality.

REL 403. Religions of the World

3 or 3

History, general characteristics, and central teachings of the major living religions of the world, with a brief consideration of contemporary secular movements that are in a sense religious.

DEPARTMENT OF PHYSICS

Professors: ARTHUR CLAYTON MENIUS, Head, FOREST WESLEY LANCASTER, JEFFERSON SULLIVAN MEARES, RAYMOND LEROY MURRAY, Graduate Administrator, RUFUS HUMMER SNYDER, NEWTON UNDERWOOD, ARTHUR W. WALTNER.

Associate Professor: JOSEPH THOMAS LYNN.

Assistant Professors: WILLIAM ROBERT DAVIS, WESLEY OSBORN DOGGETT, RAOUL M. FREYRE, DAVID H. MARTIN.

ENGINEERING PHYSICS

The Master of Science in Engineering Physics is offered to enable those students whose interest is in applied physics to obtain a basic training in the fundamental subject matter and techniques of physics in an engineering environment.

The inclusion of a number of elective courses allows for a minor in some field of engineering or mathematics.

NUCLEAR ENGINEERING

Nuclear Engineering refers to research on nuclear processes, and to design and operation of equipment in the atomic energy field. Both the knowledge of basic science and the methods of engineering are applied to the solution of the new and unusual problems encountered in this work. The need for trained engineers has grown steadily, along with the application of nuclear energy to propulsion and electrical power, to isotope production, and to radiation research in industry. The program of study in Nuclear Engineering, established in 1950 at North Carolina State College, was the first of its kind in the United States. The areas of study for the Master's candidate include:

- (a) Basic Science: Theoretical and Experimental Physics, Chemistry, and Mathematics.
- (b) Nuclear Technology: Reactor Theory and Design, Radiation Hazards and Protection, properties of nuclear reactor materials and by-products.
- (c) Elective courses in related engineering fields of interest to the student.

- (d) Research and preparation of a thesis based on independent investigation.

Doctor of Philosophy Degree

The Ph.D. degree is offered in both Engineering Physics and Nuclear Engineering. The major research interests of the Department are Experimental Nuclear and Radiation Physics, Nuclear Reactor Theory, and Theoretical Physics. Research in infrared, ultrasonics, thermodynamics and spectroscopy is also available. Arrangements may also be made to perform research in a related field of Engineering.

Research Equipment

Several nuclear machines are available for research and laboratory training. There are (a) an enriched uranium, heterogeneous water-moderated reactor of power up to 100 kilowatts, (b) a low-powered homogeneous enriched uranium "water-boiler" reactor, (c) a subcritical natural uranium assembly, (d) a one mev Van de Graaf Accelerator.

Courses for Advanced Undergraduates

- PY 401. Mechanics** 4-0
Prerequisite: PY 202.
Co-requisite: MA 301.
An intermediate course in theoretical mechanics. Statics and dynamics of particles and rigid bodies. Lectures, problems, recitations, with one laboratory per week. Mr. Meares.
- PY 402. Heat and Sound** 0-4
Prerequisite: PY 202.
Co-requisite: MA 301.
An intermediate course in the principles of thermodynamics, kinetic theory, heat transfer, and vibration. Lectures, problems, recitations and one laboratory per week. Mr. Meares.
- PY 403. Electricity and Magnetism** 4-0
Prerequisite: PY 202.
Co-requisite: MA 301.
An intermediate course in the fundamentals of static and dynamic electricity and electromagnetic theory. Lectures, problems, recitations, and one laboratory per week. Mr. Doggett.
- PY 404. Optics** 0-4
Prerequisite: PY 202.
Co-requisite: MA 301.
An intermediate course in physical and geometrical optics. Lectures, problems, recitations, and one laboratory per week. Mr. Freyre.
- PY 407. Introduction to Modern Physics** 3 or 3
Prerequisites: PY 202, MA 202.
A brief survey of the important development in atomic and nuclear physics.
Topics covered include: atomic and molecular structure, determination of the mass and charge of ions, origin of spectra, ion acceleration, nuclear reactions, and cosmic rays. Particular attention is paid to the practical applications of these developments. Staff.
- PY 410. Nuclear Physics I** 4 or 4
Prerequisite: PY 407.
An introductory treatment of the properties of nuclear particles and their interactions with matter. Consideration is given to natural and artificial radioactivity, nuclear reactions, fission, and the structure of simple nuclei. A three-hour laboratory is included. Mr. Waltner.
- PY 419. Introduction to Nuclear Engineering** 2-0
Prerequisite: PY 410.
A survey of the engineering applications of nuclear energy. The principles and practices of isotope separation, production of plutonium, and nuclear reactor operation are studied along with the peace-time uses of products and by-products of nuclear reactors. Major engineering problems involved in each phase of the study are defined and the special methods of approach indicated. Mr. Murray.

Courses for Graduates and Advanced Undergraduates

- PY 501. Wave Mechanics and Applications** 3-0
Prerequisites: PY 407 and MA 301.
An introductory course in wave mechanics with applications to the free particle, harmonic oscillator, rigid rotator, and the hydrogen atom. Includes discussion of approximation methods in the solutions of other problems. Primarily designed for a one semester introduction to wave mechanics for those students not specializing in theoretical physics. Mr. Menius.
- PY 503. Introduction to Theoretical Physics** 0-3
Prerequisites: PY 401 or 403, MA 541.
An introductory course which offers preparation necessary for advanced graduate study. The course, presented from the viewpoint of vector and tensor calculus, includes: particle dynamics, Lagrange's equations of motion, Hamilton's principle, mechanics of rigid bodies, topics in electromagnetic theory and relativity, with an elementary treatment of the motion of charged particles.
Mr. Freyre.
- PY 510. Nuclear Physics II** 4-0
Prerequisite: PY 410.
A continuation of physics 410 with particular emphasis on neutron physics, nuclear energy levels, meson theory, nuclear resonance, atomic and molecular magnetism, and cosmic radiation. A three-hour laboratory is included.
Mr. Waltner.
- PY 518. Radiation Hazard and Protection** 3 or 3
Prerequisite: PY 410.
The hazards from external exposure to ionizing radiation are evaluated. The dosages resulting from the ingestion of radioactive materials are computed. The precautionary methods used in radioactive work are presented. Selected biological effects of ionizing radiation are studied.
Mr. Underwood.
- PY 520. Physical Technology in Radioactivity** 3 or 3
Prerequisite: PY 410.
Emphasis in this course is on the physical principles used in detecting, handling, and quantitatively measuring radioactive samples. The preparation of samples for radioactivity measurements and the calculation methods used in analyzing such data are summarized. At least three hours of laboratory practice per week.
Mr. Lynn.
- PY 526. Ionization Phenomena and Electron Optics** 0-2
Prerequisites: PY 404, 410.
Methods of producing ions, and the interaction of ions with electric and magnetic fields are discussed, together with a brief survey of the present status of electron optics.
Mr. Waltner.
- PY 530. Elementary Nuclear Reactor Theory** 0-3
Prerequisites: PY 410; MA 511 or 532.
A lecture course in the principles of chain reactors. Slowing down of

neutrons, neutron diffusion equations, space distribution of neutrons, conditions for critically, reactor dimensions for simple geometries, elementary group theories, and time dependent reactor behavior. Mr. Murray.

PY 531. Nuclear Reactor Laboratory 1 or 1

Corequisite: PY 530, 518 except by permission.

Experiments are performed on the characteristics of the reactor, the effectiveness and response time of control apparatus, reactor-transient behavior; level, distribution and utilization of reactor radiation; survey, monitoring and safety techniques in procedures involving reactor radiation. Registration will be limited to suitably sized groups. Mr. Martin.

PY 541. Advanced Experiments in Physics 1-1

Prerequisites: PY 202, MA 202.

Covers the technique and theory of selected experiments in mechanics, heat, sound, light, or electricity. The treatment and interpretation of data are stressed. Graduate Staff.

PY 544. Vibration and Wave Motion 3-0

Prerequisites: PY 202, MA 401.

The dynamics of vibratory and oscillatory motion. Analogies in mechanical, electrical and acoustical vibrating systems. Analysis of wave motion and propagation in different media. Mr. Lancaster.

PY 545. Applied Acoustics 0-3

Prerequisite: PY 544.

The dynamical theory of sound. Sources of sound, measurement of sound intensity, measurement of frequency, acoustical impedance and transmission of sound, transducers, filters and resonators, acoustics of speech and hearing, reception and reproduction of sound, acoustics of buildings.

Mr. Lancaster.

PY 551. Introduction to X-Rays 3-0

Prerequisites: PY 202, MA 202.

Origin, production, absorption, single crystal diffraction, and powder diffraction are studied. These basic topics are then applied to detection or defects in welds and castings and to the determination of crystal structure and particle and fibre size. (Two 1-hour lectures and one 3-hour lab. per week.) Graduate Staff.

PY 552. Introduction to the Structure of Solids; Crystallography 0-3

Prerequisites: PY 202, MA 202; PY 551 recommended

Elementary consideration of amorphous and crystalline solids, metals, conductors, and semi-conductors. Some optical crystallography is included.

Graduate Staff.

Courses for Graduates Only

PY 601, 602. Advanced General Physics 3-3

Prerequisite: PY 503.

Co-requisite: MA 661.

Mathematical and theoretical approach to relationships between the vari-

ous branches of physics, with applications to mechanical, electrical, optical, thermal, and vibratory problems. The restricted theory of relativity, electrodynamics, the theory of electrons, classical field theory, and the general theory of relativity. Mr. Davis.

PY 610. Advanced Nuclear Physics 0-3

Prerequisites: PY 510; PY 611, except by permission.

Current hypotheses of nuclear structure and reactions including deuteron binding, neutron-proton scattering, the compound nucleus, stripping reactions, shell structure, beta decay, neutron resonances and mesons. The use of neutrons in present-day nuclear research is emphasized. Mr. Doggett.

PY 611. Quantum Mechanics 3-0

Prerequisites: PY 501, MA 512.

Theory of quantum mechanics with applications to atomic and molecular structure, scattering phenomena, and a semi-classical treatment of the interaction of radiation with matter. Mr. Davis.

PY 612. Advanced Quantum Mechanics 0-3

Prerequisites: PY 601, PY 611.

Dirac's relativistic electron theory, elementary scalar and vector meson field theory. Introduction to quantum electrodynamics and the general theory of quantized fields. Mr. Davis.

PY 619. Heterogeneous Reactor Design 3-0

Prerequisite: PY 530.

Design analysis of heterogeneous power reactors. Theory of resonance capture, thermal utilization, and flux distributions in multi-region systems. Transient and steady state poison effects. Heat transfer limitations in reactors. Evaluation of materials of construction, coolants and fuels. One-velocity transport theory. Mr. Murray.

PY 620. Nuclear Radiation Attenuation 3-0

Prerequisites: PY 530, MA 532.

Physical theory of neutron and gamma-ray behavior in matter. Calculations of source terms, attenuation factors, heating rates, geometrical transformations and radioactive decay effects required in the design of nuclear radiation shields. Transport theory of gamma-ray and neutron transmission through matter. Analysis of experimental techniques for obtaining shielding data. Mr. Doggett.

PY 621. Kinetic Theory of Gases 3-0

Prerequisites: PY 503, MA 511.

The theory of molecular motion, including the velocity and density distribution functions, the phenomena of viscosity, heat conduction and diffusion; equations of state; fluctuations. Mr. Menius.

PY 622. Statistical Mechanics 0-3

Prerequisites: PY 503, MA 511; PY 621 except by permission.

A treatment of statistical mechanics from both the quantum and classical point of view. Development of theories from the thermodynamical standpoint and their practical application. Mr. Davis.

PY 630. Homogeneous Reactor Design

0-3

Prerequisite: PY 530.

Calculations of critical loading of homogeneous power reactors, flux distribution, control rod values, theory of two and multigroup methods, and evaluation of group constants. Uses and limitations of age and diffusion theory. Energy-dependent transport theory. The time-dependent behavior of a reactor with negative temperature coefficient.

Mr. Murray.

PY 631, 632. Atomic and Molecular Spectra

3-3

Prerequisites: PY 501. Corequisites: PY 611, MA 532.

Atomic models and coupling schemes. Multiplet series, Zeeman, Paschen-Back, and Stark effects. Hyperfine structure and complex spectra. Spectra of polyatomic molecules. Infrared and Raman Spectra. Applications adapted to the interests of the students in the course.

Mr. Lancaster.

PY 661, 662. The Solid State

3-3

Prerequisite: PY 552.

The electron theory of conduction, electrical and thermal conduction in solids, and surface phenomena, with applications to physical behavior and usage of solids.

Graduate Staff.

PY 670. Seminar.

1-1

Literature surveys, written and oral presentation of papers on special topics.

Graduate Staff.

PY 690. Research

Credits by arrangement

Graduate students sufficiently prepared may undertake research in some selected field of Physics.

Graduate Staff.

DEPARTMENT OF PLANT PATHOLOGY

Graduate Faculty

Professors: D. E. ELLIS, Head, C. N. CLAYTON, F. A. HAASIS, T. T. HEBERT, A. KELMAN, E. L. MOORE, L. W. NIELSEN, C. J. NUSBAUM.

Professor Emeritus: S. G. LEHMAN.

Associate Professors: J. L. APPLE, ROBERT AYCOCK, G. B. LUCAS, R. R. NELSON, J. N. SASSER, N. N. WINSTEAD.

Assistant Professors: W. E. COOPER, HEDWIG HIRSCHMANN, D. M. KLINE, ROBERT T. SHERWOOD.

The Master of Science and Doctor of Philosophy degrees are offered in Plant Pathology.

Excellent laboratory and greenhouse facilities are available for graduate study in plant pathology including special equipment for all phases of phytopathological research. The state's wide range of soil types and climatic areas make possible the commercial production of a wide variety of field, vegetable, fruit and ornamental crops. Thus, especially favorable opportunities exist for training in diseases caused by nematodes, viruses, fungi and bacteria which affect many diverse crops. Land and facilities for experimental work are available at some sixteen permanent research stations located throughout the state. Student participation in the Plant Disease

Clinic provides excellent training and experience in the diagnosis of all types of plant diseases.

Many opportunities for employment in research, extension, and teaching are available to men with M.S. or Ph.D. degrees in plant pathology. Openings are available for qualified men in plant pathology research in the United States Department of Agriculture, State Experiment Stations and in Industry. Unusual opportunities exist in foreign service through international and federal organizations as well as commercial production enterprises. The rapid development of agricultural chemicals for disease control offer numerous opportunities in both research, promotion and service activities.

Courses for Advanced Undergraduates and Graduates

*****PP 503. Diagnosis of Plant Diseases** Summer School 3

Prerequisites: One advanced course in Plant Pathology and permission of instructor.

A study of techniques used in plant disease diagnosis with emphasis on diagnostic value of signs and symptoms for certain types of diseases.

Consideration will be given to major sources of descriptive information on plant pathogens and the use of keys for the identification of fungi.

Mr. Hebert.

PP 515. Diseases of Field Crops 0-3

Prerequisite: PP 315.

An advanced study of the more important diseases of North Carolina field crops such as cotton, corn, tobacco, soybeans, alfalfa, clover, grasses, and small grains with major emphasis on identification, cause and control.

Mr. Lucas.

****PP 516. Diseases of Fruit Crops** 0-3

Prerequisite: PP 315.

Study of causes, symptoms, epiphytology, and principles of control of major diseases of pome, stone, nut, and berry crops.

Mr. Clayton.

***PP 517. Diseases of Vegetable Crops** 0-3

Prerequisite: PP 315.

Studies designed to provide the student with a working knowledge of the etiology, symptomatology, epiphytology, and control of major vegetable crop diseases.

Mr. Winstead.

Courses for Graduate Students Only

PP 601. Phytopathology I 4-0

Prerequisites: PP 315 and permission of the instructor.

A study of the principles of phytopathological research. The course is designed to apply the classical scientific method to disease investigation. Exercises will include appraising disease problems, reviewing literature, laboratory and greenhouse experiments and the evaluation and presentation of data.

Mr. Apple.

*Offered 1960-61 and in alternate years.

**Offered 1961-62 and in alternate years.

***Offered Summer, 1960 and in alternate years.

- *PP 602. Phytopathology II** 0-4
 Prerequisites: PP 315 and permission of the instructor.
 The basic concepts of the etiology, pathology, epiphytology and control of plant diseases. Mr. Nusbaum.
- PP 604. Plant Parasitic Nematodes** 2-0
 Prerequisite: PP 315.
 A study of morphology, anatomy, physiology and taxonomy of plant parasitic nematodes. Methods of isolating nematodes from soil and plant parts and other laboratory techniques used in the study and identification of nematodes will be considered. Miss Hirschmann.
- *PP 605. Plant Virology** 3-0
 Prerequisites; PP 315, GN 411, and a course in organic chemistry.
 A study of plant viruses including effects on host plants, transmission, classification, methods of purification, determination of properties, chemical nature, structure and multiplication. Mr. Hebert.
- *PP 607 and GN 607. Genetics of Fungi** 3-0
 Prerequisites: GN 512, or equivalent and permission of instructor.
 Review of major contributions in fungus genetics with emphasis on principles and theories that have evolved in recent developments. Mr. Nelson.
- **PP 608. History of Phytopathology** 1-0
 Prerequisites: PP 315 and permission of instructor.
 Development of the science of phytopathology from its early beginnings to the early part of the 20th century. Mr. Ellis.
- PP 611. Nematode Diseases of Plants** 0-3
 Prerequisite: PP 504.
 A study of plant diseases caused by nematodes. Special consideration will be given to host-parasite relationships, host ranges, and life cycles of the more important economic species. Principles and methods of control will be considered. Mr. Sasser.
- PP 615. Research in Plant Pathology** Credits by arrangement
 Prerequisites: Graduate standing and consent of instructor.
 Original research in connection with a thesis problem in Plant Pathology. Graduate Staff.
- PP 625. Seminar in Plant Pathology** 1-1
 Prerequisite: Consent of seminar chairman.
 Discussion of phytopathological topics selected and assigned by seminar chairman. Graduate Staff.
- UNC. Botany 212, 211. Advanced Mycology** 5-5
 Prerequisite: BO 42 or 101 (UNC) or equivalent.
 Phycomycetes, Ascomycetes, Basidiomycetes and Fungi Imperfecti. These courses are intended for students who plan to specialize in Mycology, Plant Pathology, and Biology. Classwork consists of lectures and student reports

*Offered 1960-61 and in alternate years.

**Offered 1961-62 and in alternate years.

on literature. Laboratory work consists of the collection and identification of fungi and the study of their structure and development, and techniques for isolation and pure culture.

Two hours of lecture and four hours of laboratory each week.

Mr. Couch.

DEPARTMENT OF POULTRY

Graduate Faculty

Professors: EDWARD WALKER GLAZENER, Head, CLIFFORD WARREN BARBER, CHARLES HORACE HILL, JR.

Associate Professors: HENRY WILBURN GARREN, JOSEPH WHEELER KELLY.

Assistant Professors: WILLIAM LOWRY BLOW, FREEMAN WALDO COOK, DANIEL FROMM.

The M. S. degree is offered in Poultry Science with major studies in genetics, nutrition, veterinary pathology, and physiology. Students expecting to begin graduate study must have the equivalent of an undergraduate major in poultry and a background in the biological sciences. Fundamental work in chemistry, biochemistry, physiology, bacteriology, statistics, and fields that relate directly to the major interest are required as a part of the program for the M. S. degree.

Excellent facilities are available for graduate study. The laboratory building contains offices, library, bird rooms, and other equipment for comprehensive research studies. In addition to the laboratory building, research plants in both chickens and turkeys are available. These plants, with three branch farms located in the western, piedmont and eastern part of the State, provide an opportunity for genetic and nutrition studies under field conditions.

To offer wider scope to the regular programs of work, cooperative projects are underway with the U.S.D.A. in genetics and pathology.

Many opportunities exist in educational and commercial fields for poultry majors with advanced degrees. The larger feed manufacturers, hatcherymen, and commercial breeders as well as educational institutions are demanding men with advanced training. The supply of trained men is limited and starting salaries are adequate.

Courses for Advanced Undergraduates

PO 401. Poultry Diseases

0-4

Prerequisites: Required of majors in Poultry Science. Elective for others with permission of the instructor.

The prevention, control, and treatment of the diseases of poultry.

Mr. Barber.

PO 402. Commercial Poultry Enterprises

0-4

Prerequisites: Required of majors in Poultry Science. Elective for others with permission of the instructor.

Principles of incubation, hatchery management, development and organization of plans for the building, operation, and maintenance of a commercial poultry plant. Problem.

Mr. Brown.

PO 403. Poultry Seminar

1-1

Prerequisites: Required of majors in Poultry Science, senior year.

Topics and problems relating to Poultry Science and Poultry Industry assigned for report and discussion.

Staff.

Courses for Graduates and Advanced Undergraduates

PO 520. Poultry Breeding 3-0

Prerequisites: GN 411. Required of majors in Poultry Science.

Elective for others with permission of the instructor.

Application of genetic principles to chickens and turkeys, considering physical traits and physiological characteristics—feather patterns, egg production, hatchability, growth, body conformation, and utility. Laboratory problems. Mr. Glazener.

PO 521. Poultry Nutrition 3-0

Prerequisites: CH 203, 451. Required of majors in Poultry Science; elective for others.

Protein, vitamin, and mineral requirements for growth, egg production, and reproduction in the chicken and turkey. Methods of feeding and compounding poultry mash. Laboratory exercises in the production of vitamin and mineral deficiencies. Mr. Kelly.

PO 522. Endocrinology of the Fowl 0-3

Prerequisite: ZO 301 or equivalent.

Study of the endocrine system with respect to its physiological importance to metabolism, growth, and reproduction. Mammalian examples as well as the fowl are used to illustrate basic concepts. Laboratory techniques and demonstrations. Mr. Garren.

Courses for Graduates Only

PO 601. Advanced Poultry Breeding Semester by arrangement 3 credit hours

Prerequisites: ST 511 and 512, PO 520.

Study of lethal, skeletal, and feather variations. Linkage and chromosome mapping of the fowl. Population genetics and contemporary ideas concerning the breeding for improved production. Mr. Blow.

PO 602. Advanced Poultry Nutrition Semester by arrangement 3 credit hours

Prerequisites: PO 521, CH 551 or equivalent.

Research problem in poultry nutrition involving the design and carrying out of microbiological and chick experiments. Results from microbiological and chick essays are correlated. Mr. Hill.

PO 611. Poultry Research Credits by arrangement

Prerequisite: Graduate standing in Poultry Science.

Critical study of some particular problem involving original investigation. A maximum of six credits is allowed toward the Master's degree.

Graduate Staff.

PO 613. Special Problems in Poultry Science Max. 6

Prerequisite: Graduate standing.

Specific problems using advanced technology for theory exploration.

Graduate Staff.

DEPARTMENT OF PSYCHOLOGY

Professors: HOWARD G. MILLER, Head; KEY L. BARKLEY, HAROLD M. CORTER.
Associate Professors: JOHN OLIVER COOK, JOSEPH CLYDE JOHNSON, SLATER
E. NEWMAN, PAUL J. RUST.
Assistant Professor: CLIFTON W. GRAY.
Instructor: DONALD W. DREWES.
Visiting Professor: WILLIAM MCGEHEE.

The Psychology Department offers courses leading to the Master of Science Degree. An industrial option includes courses in the application of scientific methods to the study of industrial behavior based on strong research training. An experimental option provides a program with major emphasis on the development of proficiency in experimental methodology in psychological research. Courses are also offered which provide professional competence in school psychology.

All programs are designed to provide the student with solid grounding in the basic areas of psychology. A set of required core courses includes statistics, social psychology, experimental psychology, psychology of personality, and the theory and method of measurement.

A minimum of thirty semester hours of graduate credit is required for the Master's Degree, but the actual graduate program for each student is determined on the basis of his individual needs, interests and accomplishments and very likely will require hours in excess of this minimum.

Admission requirements for graduate study in the Department of Psychology are as follows: A minimum of twenty semester credit hours in undergraduate psychology, the maintenance of a B average in undergraduate psychology courses; satisfactory grades in other collegiate studies; satisfactory references from faculty and others in regard to character and quality of work. In some special cases provisional acceptance is granted where some of the requirements are not met.

The Psychology Department is housed in Tompkins Hall. The physical facilities for the training of graduate students in psychology include testing, statistics, general and human engineering laboratories.

In addition to teaching and basic research activities, the Psychology Department carries on research for industrial, military and other organizations. To facilitate this activity, the Industrial Psychology Center has been established as a special organization within the Department.

Employment opportunities for persons holding the Master's Degree in industrial psychology are excellent. Recent graduates from the industrial psychology program at State College have found responsible positions in business and industrial organizations, in government agencies, especially those engaged in research of an applied nature. The armed forces likewise continue to need trained psychologists in their research programs. Many of our students elect to continue graduate study toward the doctorate in psychology. Their master's program in addition to providing them with good professional training has proved to be excellent preparation for further graduate study.

A limited number of research and teaching assistantships are available annually. These assistantships are usually based on one-third time assignments, but are also occasionally for one-half time.

Courses for Advanced Undergraduates

PSY 438. Industrial Psychology II

0-3

Prerequisites: PSY 200, 337.

The application of psychological principles to the problems of modern industry; selection, placement, and training of workers. Messrs. Drewes, Gray, Miller.

PSY 441. Human Factors in Equipment Design

0-3

Prerequisite: PSY 200.

Human factors in the design of machines and other equipment. Items of equipment are understood as extensions of man's capacity to sense, comprehend, and control his environment. Includes problems in the psychology of information, communication, control and invention. Messrs. Cook, Gray.

PSY 464. Visual Perception for Designers

3-0

Prerequisite: PSY 200.

The nature of the seeing process and its relation to architecture, industrial arts, and to the industrial, engineering, and textile design fields. Topics include the physical basis of sight, perception of color and form, vision and illumination, psychological factors in visual design, and a unit of training planned to improve the student's ability to perceive visual form. Mr. Cook.

PSY 475. Child Psychology

0-3

Prerequisite: PSY 200 or 304.

The development of the individual child of the elementary school age will be the inclusive object of study in this course. Emphasis will be placed upon the intellectual, social, emotional, and personality development of the child. Physical growth will be emphasized as necessary to an understanding of the psychological development of the pupil. Mr. Barkley.

(Course offered during Summer session only)

PSY 476. Psychology of Adolescence

2 or 2

Prerequisite: PSY 200 or 304.

Mental growth, social development, and interests of adolescent boys and girls. Messrs. Johnson, Barkley.

PSY 490. Social Psychology

0-3

Prerequisite: PSY 200

Social applications of psychology: social stimulation, response, and attitudes. Messrs. Barkley, Miller.

Courses for Advanced Undergraduates and Graduates

PSY 501. Intermediate Applied Experimental Psychology

Prerequisite: Psychology 200 and three additional hours in Psychology.

Experimental study of problems in the major areas of general and theoretical psychology which have special significance in educational, industrial, and applied social psychology. Emphasis will be placed upon description of problems, study of methods, design of experiments, and procedures for the analysis and presentation of data. Two lectures and one laboratory period per week. Messrs. Barkley, Cook, Newman.

PSY 502. Physiological Psychology

3-0

Prerequisites: 12 hours of Psychology, including Psy. 200 and 201.

A survey of the physiological bases of behavior including the study of coordination, sensory processes, brain functions, emotions, and motivation. Mr. Corter.

PSY 504. Advanced Educational Psychology

0-3

Prerequisite: Six hours in psychology.

An advanced course giving a critical appraisal and a consideration of

the practical applications for education of modern psychological findings.

Messrs. Johnson, Newman.

(Course offered during Summer session only)

PSY 511. Advanced Social Psychology 3-0

Prerequisites: Psychology 200 and three additional hours in Psychology.

A study of social relationships and their psychological bases; emphasis on those aspects of behavior determined by personal interactions; work will involve analysis of representative research studies, and doing individual projects in industrial and rural areas.

Messrs. Barkley, Miller.

PSY 514. Current Problems in Psychology 1-0

Prerequisite: Graduate standing in Psychology.

A study of current developments in theory and research in several areas of psychological interests.

Graduate Staff.

PSY 530. Abnormal Psychology 0-3

Prerequisites: PSY 200, 302.

A study of the causes, symptomatic behavior, and treatment of the major personality disturbances, emphasis also placed on preventive mental hygiene methods.

Mr. Corter.

PSY 535. Tests and Measurements 3-0

Prerequisite: Six hours in Psychology.

A study of psychological tests, with emphasis on proper selection and use of testing instruments; also a study of statistical procedures needed in the proper use of tests, including measures of central tendency, variability and correlation.

Messrs. Gray, Johnson.

PSY 550. Mental Hygiene in Teaching 3-0

Prerequisite: Four hours in Psychology.

A survey of mental hygiene principles applicable to teachers and pupils; practical problems in prevention and treatment of psychological problems in schools; case studies and research.

Messrs. Barkley, Corter.

PSY 565. Industrial Management Psychology 0-3

Prerequisites: PSY 200 and three additional hours in Psychology.

This course is designed for management personnel in industry and graduate students in psychology who wish to familiarize themselves with psychological approaches to industrial problems. Emphasis will be placed on principles and methods for obtaining better utilization of employee resources of ideas, attitudes and motivations.

Mr. Miller.

PSY 570. Intelligence and Personality: Theory and Measurement I 3-0

Prerequisites: PSY 200 and three additional hours in Psychology.

An introduction to individual personality and intelligence testing, theoretical background of intelligence and personality.

Mr. Corter.

PSY 571. Intelligence and Personality: Theory and Measurement II 0-3

Prerequisite: PSY 570.

A practicum in individual intelligence testing with emphasis on the Wechsler-Bellevue, Stanford-Binet, report writing, and case studies.

Mr. Corter.

PSY 572. Intelligence and Personality: Theory and Measurement III . 0-3

Prerequisite: PSY 570 and 571.

A practicum in individual personality testing of infants, children and adults with emphasis on projective techniques, other tests, report writing, case studies, and consultation with teachers.

Mr. Corter.

(Course offered during Summer session only)

PSY 576. Developmental Psychology 3-0

Prerequisite: Nine hours in Psychology, including PSY 476 or 475.

A survey of the role of growth and development in human behavior; particularly at the child and adolescent periods. This course will pay particular attention to basic principles and theories in the area of developmental psychology.

Mr. Johnson.

PSY 578. Individual Differences 3-0

Prerequisite: Four hours in Psychology

Nature, extent, and practical implications of individual differences and individual variation.

Mr. Barkley.

Courses for Graduates Only

PSY 604. Applied Experimental Psychology 0-3

Prerequisite: PSY 501.

Experimental analysis of problems of sensation, perception, learning, thinking, emotions, fatigue, and neuro-muscular reactions. Emphasis upon methods of experimental control, design of experimental apparatus, and accuracy of reports as these are related to laboratory investigations in the fields of applied psychology.

Messrs. Barkley, Cook, Newman.

PSY 606. Behavior Theory 3-0

Prerequisites: PSY 200, a course in learning, experimental psychology, and statistics.

A study of the most fundamental considerations in behavior theory. Such topics as criteria of scientific meaningfulness, the nature of scientific explanation, the application of formal, logical techniques to theory analysis, the nature of probability, operationism, intervening variables, etc. will be covered. The aim of the course is to develop skill in handling theoretical concepts, the ability to analyze and evaluate theories, to deduce hypotheses from them, and to devise means of testing them.

Mr. Cook.

PSY 607. Advanced Industrial Psychology I 3-0

Prerequisites: One undergraduate course beyond general psychology in applied or experimental psychology.

Application of scientific methods to the measurement and understanding of industrial behavior.

Messrs. Drewes, Gray, Miller.

PSY 608. Advanced Industrial Psychology II 0-3

Prerequisites: One undergraduate course beyond general psychology in applied or experimental psychology.

Practical applications of the methods of industrial psychology.

Messrs. Drewes, Gray, Miller.

PSY 609. Psychological Clinic Practicum

Maximum 3 hours

Prerequisite: Eight hours in Psychology.

Clinical participation in interviewing, counseling, psychotherapy and administration of psychological tests. Practicum to be concerned with adults and children.

Mr. Corter.

PSY 610. Theories of Learning

Prerequisite: Eight hours in Psychology.

A study of theories of learning with emphasis upon applications of the principles of learning.

Messrs. Barkley, Johnson, Newman.

PSY 612. Seminar in Industrial Psychology

3 or 3

Scientific articles, analysis of experimental designs in industrial psychology, and study of special problems of interest to graduate students in Industrial Psychology.

Graduate Staff.

PSY 613. Research in Psychology

Credits by arrangement

Individual or group research problems; a maximum of six credits is allowed toward the Master's degree.

Graduate Staff.

DEPARTMENT OF RURAL SOCIOLOGY

Graduate Faculty

Professors: CHARLES HORACE HAMILTON, SELZ CABOT MAYO.

Assistant Professor: GLENN C. MCCANN, JAMES N. YOUNG.

The Master of Science and the Doctor of Philosophy degrees are offered by the Department of Rural Sociology.

Graduate students studying for the Ph.D. degree are required to take approximately 15 semester hours in the Department of Sociology at the University of North Carolina, Chapel Hill, N. C. Students seeking the M.S. degree may take courses at Chapel Hill, but normally will be able to complete their entire programs at State College.

The physical and educational resources of this department which are available to graduate students include the following: (1) A departmental library of bulletins, monographs, and other materials consisting of several thousand items, accumulated over a period of 30 years, and catalogued in indexed files; (2) Laboratory equipment consisting of calculating machines, drawing table and instruments, chart making materials, cameras, typewriters, and statistical aids; (3) Automobiles for use in making field surveys; (4) IBM tabulating equipment, operated by the Department of Experimental Statistics.

Providing, as it does, training in a number of social sciences, Rural Sociology at State College prepares the graduate student for a wide variety of positions. Men and women with graduate degrees in rural sociology have opportunities for careers in college teaching, sociological research, social statistics, social work, administration of social organizations and governmental agencies, agricultural journalism, and in those branches of the government's foreign service relating to agriculture and the underdeveloped areas of the world.

Institutions offering employment to graduates are: Land-Grant Colleges, Agricultural Experiment Stations and Extension Services; the United States

Departments of Agriculture, State, and Health, Education and Welfare; state departments of health, education and welfare; farm journals and newspapers; and, voluntary social agencies, such as Red Cross, Community Chest, Boy Scouts, and National Tuberculosis Association.

Each year two or more outstanding graduate students are awarded research assistantships, usually requiring the devotion of half of their time to a research project. Cooperative research work with various governmental agencies frequently provides part-time employment for graduate students.

Couses for Advanced Undergraduates and Graduates

RS 511. Rural Population Problems 3-0

Prerequisite: RS 301.

A study of population growth, rates of change, and distribution. Considerable attention is given to the functional roles of population, i.e., age, sex, race, residence, occupation, marital status, and education. The dynamic aspects of population are stressed: fertility, mortality, and migration. Population policy is analyzed in relation to national and international goals. A world view is stressed throughout.

Mr. Mayo.

RS 513. Community Organization 3-0

Prerequisite: RS 301.

Community organization is viewed as a process of bringing about desirable changes in community life. Community needs and resources available to meet these needs are studied. Democratic processes in community action and principles of community organization are stressed, along with techniques and procedures. The roles of leaders, both lay and professional, in community development are analyzed.

Mr. Mayo.

UNC Philo. 107. Foundations of the Social Sciences 0-3 (1959-60 and alternate years)

Prerequisites: Two courses in philosophy, psychology or sociology.

An inquiry into the nature of social reality through an examination of the basic concepts of sociology, history, etc. Behavioral and subjective approaches are contrasted. Both methodological and more broadly philosophical problems are discussed.

Mr. Natanson.

UNC Anthro. 119. Culture and Personality 3-0

Personality, growth, and child-rearing seen in cross cultural perspective; cultural factors explored as they may be related to psychopathology and psychotherapy; opportunity will be given for the student to make meaningful observations of socialization in his own community.

Mr. Honigmann.

UNC Soc. 122. Cultural Anthropology 3-0

A systematic survey of the customs and modes of life of mankind based on scientific explanation of the ways of culture. Fee: \$1.00. Mr. Johnson.

UNC Soc. 125. The Negro 0-3

A study of the Negro community and its relations, status of the Negro

in American society, problems of race relations, and the process of integration.

UNC Soc. 128. Folk Cultures in the Modern World 0-3
(1959-60 and alternate years.)

The folk culture is viewed as a way of life which stands midway between that of the "primitive" tribal native and of the urbanized city dweller. Fee: \$1.00.

RS 534. (HI 534.) The Farmers' Movement 0-3
Prerequisite: 3 hours of sociology.

A history of agricultural organizations and movements in the United States and Canada principally since 1865, emphasizing the Grange, the Farmers' Alliance, the Populist revolt, the Farmers' Union, the Farm Bureau, the Equity societies, the Nonpartisan League, cooperative marketing, government programs, and present problems. Mr. Noblin.

UNC Soc. 152. History of Social Thought 3-0
Prerequisite: One course in one of the social sciences or philosophy.

Emphasis on historic social ideas of Western culture considered against a background of general cultural analysis in terms of systematic theory. Mr. Vance.

UNC Soc. 153. Social Structure 3-0
Analysis of social structure and stratification in terms of class, status, prestige, rank, and function. Attention is given to the social role of the elite, bureaucracies, and professional and middle classes. Mr. Vance.

UNC Soc. 161. Sociology of the Family 0-3
Analysis of the family institution as a background for the study of family interaction: socialization and the parent-child relationship, courtship and marriage interaction, family crises and problems. Mr. Bowerman.

UNC Soc. 168. The City 0-3
The city as a social phenomenon in various cultures. Analysis of urban trends, characteristics, and functions of cities with reference to ecology and social organization. Sociological elements in housing, urban planning, and guided development. Fee: \$1.00. Mr. Vance.

UNC Soc. 181. Regional Sociology of the South 0-3
A sociological analysis of the southern region of the United States. Emphasis on fact, factors, and policies pertaining to geography, population and culture; resources and waste; social institutions and planning. Fee: \$1.00. Mr. Simpson.

Courses for Graduates Only

UNC Soc. 210. Folk Sociology 3-0
Folk sociology as a subject field for the historical study of total human society and the empirical study of group behavior. Mr. Simpson.

RS 611. Research Methods in Sociology 3-0
Prerequisite: 6 hours of sociology.

Designed to give the student a mature insight into the nature of scientific research in sociology. Assesses the nature and purpose of research designs, the interrelationship of theory and research, the use of selected techniques and their relation to research designs, and the use of modern tabulation equipment in research.

Mr. McCann.

UNC Soc. 212. American Sociologists 0-3

A general treatise on the rise and development of American sociology and a survey of the work personalities of American sociologists projected on the background of social theory and research.

Mr. Simpson.

UNC Soc. 218. Human Ecology (Seminar) 0-3
(1960-61 and alternate years.)

Consideration of theory and research emerging around the concept of human ecology. A review of the background of human ecology is followed by readings, reports, and research on its contemporary development. Fee: \$1.00.

Mr. Vance.

UNC Anthro. 220. Theories of Culture 0-3
(1959-60 and alternate years.)

A systematic survey of the history in cultural anthropology leading to the development of a system of operational principles which the student may apply in his own fieldwork and further studies involving cultural problems. Fee: \$1.00.

RS 621. Rural Social Psychology 3-0
Prerequisite: 6 hours of sociology.

Treats the genetic development of the rural personality and the inter-relationship of the individual and the rural society. Studies the social psychological factors related to rural leadership, morale, social organization, and social change, and examines the attitudes and opinions of rural people on current local and national issues.

Mr. McCann.

UNC Anthro. 221. Field Methods in Cultural Anthropology 0-3

Practical exercises and discussion cover topics of role taking, observation, interviewing, note taking, and pattern generalization. Fee: \$1.00.

Mr. Honigmann.

UNC Anthro. 230. Race and Culture Contacts 0-3

An analysis of acculturation situations arising from contacts of peoples of different racial or cultural heritages in America, Africa, Polynesia, Melanesia, and other areas.

Mr. Johnson.

RS 631. Population Analysis 0-3
Prerequisite: 6 hours of sociology.

Methods of describing, analyzing, and presenting data on human populations: distribution, characteristics, natural increase, migration, and trends in relation to resources.

Mr. Hamilton.

RS 632. Rural Family 3-0
Prerequisite: 6 hours of sociology.

Emphasis is placed on the development of an adequate sociological frame of reference for family analysis; on discovering both the uniquely-cultural

and common-human aspects of the family by means of cross-cultural comparisons; on historical explanations for variability in American families with especial concern for the rural family; and, on analyzing patterns of family stability and effectiveness. Mr. Hamilton.

RS 633. The Rural Community 0-3

Prerequisite: 6 hours of sociology.

The rural community is viewed in sociological perspective as a functioning entity. A method of analysis is presented and applied to eight "dimensions," with emphasis on the unique types of understanding to be derived from measuring each dimension. Finally, the effect of change on community integration and development is analyzed. Mr. Mayo.

UNC Soc. 262. European Sociological Theory 3-0

The role of theory in sociological research. Analysis and comparison of major methodological and theoretical orientations in sociology. Development from European backgrounds of current theories of social differentiation, social integration, social change, structural-functional analysis and social systems analysis. Mr. Simpson.

UNC Soc. 333. Seminar in Marriage and the Family 3-0
(1961-62 and alternate years.) Mr. Bowerman.

UNC Soc. 334. Critique of Research in Marriage and the Family 3-0
(1960-61 and alternate years.)

This seminar reviews the basic conceptual frameworks used in family research in the past; identifies changing emphasis in family study; and evaluates current studies in the major fields of family research.

Mr. Bowerman.

UNC Psych. 233. Methods of Investigation in Social Psychology 0-3

Methods of investigation in social psychology with application to the social sciences. Survey methodology with particular emphasis on techniques, contributions, and limitations of public opinion polling. Mr. Thibaut.

RS 641. Statistics in Sociology 3-0

Prerequisite: Statistics 513.

The application of statistical methods of sociological research. Emphasis on selecting appropriate models, instruments, and techniques for the more frequently encountered problems and forms of data. Mr. Hamilton.

RS 642. Research in Rural Sociology Credits by arrangement

Prerequisite: Permission of chairman of graduate study committee. (Maximum of six credits.)

Planning and execution of research, and preparation of manuscript under supervision of graduate committee. Staff.

RS 653. Theory and Development of Rural Sociology 0-3

Prerequisite: 6 hours of sociology.

Required of all masters and doctoral candidates in rural sociology and is recommended for all graduate minors. Designed to meet two objectives: (1) to introduce the student to the study of current sociological theory, and (2)

to survey events and trends in the historical development of rural sociology.
Mr. Hamilton.

UNC Religion 270. Sociology of Religion 0-3

Analysis of tensions between the scientific, ethical, and theological study of society; the role of religion in social change; the social origins of the denominations; the sociological significance of the Reformation; "sect" and "church" in sociological theory.
Mr. Nash.

RS 671. Seminar Credits by arrangement

Appraisal of current literature; presentation of research papers by students; progress reports on departmental research; review of developing research methods and plans; reports from scientific meetings and conferences; other professional matters. (A maximum of three credits is allowed toward the master's degree, and six credits toward the doctorate.)
Staff.

DEPARTMENT OF SOCIOLOGY AND ANTHROPOLOGY

Graduate Faculty

Professor: SANFORD RICHARD WINSTON.

Associate Professors: ELMER HUBERT JOHNSTON, HORACE D. RAWLS.

Assistant Professor: JOHN W. TOMLIN.

No program leading to graduate degrees is offered in sociology and anthropology as such at State College. The course of work listed below is acceptable for graduate credit as part of a program in some other area of graduate study.

Courses for Advanced Undergraduates

SOC 401. Human Relations in Industrial Society 3 or 3

Selected societies about the world are contrasted with American society to demonstrate the correlation between technology and general behavior patterns, both within industry and in the total social order. The patterns of adjustment by the individual to the organizational framework (business concern, manufacturing enterprise, etc.) are analyzed in terms of social status, social roles, work norms, and attitudes. The social significance of major characteristics of contemporary industry is considered in terms of such topics as enlargement of the geographic bounds of the human community, development of occupational specialization, alteration of the character of inter-group interaction, and the growing integration of American culture. The interrelationships between industry and social change are discussed to show the effect of new social conditions upon industrial operations and the effect of technological change upon the family, school, church, and government. The contribution of industry to social progress is analyzed to promote the student's understanding of the dynamic quality of the social environment within which he will function.

SOC 402. Urban Sociology 3 or 3

The course begins with a study of the factors behind the organic growth of cities. The relationship between the physical design of cities and their social organization is discussed. This is followed by a detailed analysis of new developments in the serving of human needs (adequate housing, and the design of physical and social structures for religious, educational, public welfare, and recreational activities). Socio-psychological aspects of life in an urbanized society are compared with those of predominantly agricultural societies. The increasing integration of urban and rural living is emphasized. Finally, the changing character of urban life is seen in the resulting demand for city and regional planning and the use of administrative personnel having both technical and social backgrounds.

SOC 411. Community Relationships 3 or 3

A survey of the institutions, organizations, and agencies to be found in modern communities; the social conditions or problems, such as recreation, health, welfare, etc., with which they deal; their inter-relationship and the trend toward over-all planning.

SOC 412. Introduction to Social Work 3 or 3

An introductory course, designed to acquaint students with the various types of public

and private social work and with remedial and preventive programs in applied sociology, social psychiatry, health, public welfare, and recreation.

SOC 414. Social Structure 3 or 3
Studies of the major social institutions and systems of stratification: the organization of social systems as, for example, religion, education, and government; the functions of such structural components as age and sex groups, vocational and professional groups, and social classes. Messrs. Winston, Johnson.

SOC 416. Research Methods 3 or 3
An analysis of the principle methods of social research; the development of experiments; schedules and questionnaires; the measurement of behavior. Messrs. Winston, Johnson.

Courses for Graduates and Advanced Undergraduates

SOC 501. Leadership 3 or 3
Prerequisites: SOC 202, SOC 301, or equivalent.

A study of leadership in various fields of American life; analysis of the various factors associated with leadership; techniques of leadership. Particular attention is given to recreational, scientific, and executive leadership procedures. Mr. Winston.

SOC 502. Society, Culture, and Personality 3 or 3
Prerequisites: SOC 202, SOC 301, or equivalent.

Human personality is studied from its origins in primary groups through its development in secondary contacts and its ultimate integration with social norms. While comparative anthropological materials will be drawn upon, emphasis is placed upon the normal personality and the adjustment of the individual to our society and to our culture. The dynamics of personality and character structure are analyzed in terms of the general culture patterns and social institutions of society.

Messrs. Rawls, Winston.

SOC 505. The Sociology of Rehabilitation 3 or 3
Prerequisites: SOC 202, SOC 301, or equivalent.

The course stresses the social and cultural implications of the rehabilitation approach. Emphasis is placed upon the social and personal problems of physically and mentally handicapped persons. The interrelationships of the major social environments are considered at length in this regard. Objectives of the rehabilitation processes are analyzed in terms of the sociology of work. A major portion of the course is devoted to rehabilitation as a profession, particular attention being given to the diverse roles of specialists in this field. Mr. Rawls.

SOC 510. Industrial Sociology 3 or 3
Prerequisites: SOC 202, SOC 301, or equivalent.

Industrial relations are analyzed as group behavior with a complex and dynamic network of rights, obligations, sentiments, and rules. This social system is viewed as an interdependent part of total community life. The background and functioning of industrialism are studied as social and cultural phenomena. Specific social problems of industry are analyzed.

Mr. Johnson.

SOC 511. Social Theory 3 or 3
Prerequisites: Nine semester hours of sociology, or equivalent work in related fields, and permission of instructor.

The study of social theories from the earliest recorded thinkers to those

of modern times; the evolution of theories of the individual, groups, culture, community, and society; the modern development of sociology and anthropology, and interpretive systems accompanying these developments.
Graduate Staff.

SOC 515. Research in Applied Sociology

3-3

Prerequisites: SOC 202, SOC 301, or equivalent.

Individual research problems in applied fields of sociology, such as problems of the family, population, and social work; rural-urban relations; student success; American leadership.
Graduate Staff.

DEPARTMENT OF SOILS

Graduate Faculty

Professors: JAMES WALTER FITTS, Head, WILLIAM VICTOR BARTHOLOMEW, NATHANIEL TERRY COLEMAN, JAMES FULTON LUTZ, WILLIE GARLAND WOLTZ, WILLIAM WALTON WOODHOUSE, JR.

Associate Professors: EUGENE J. KAMPRATH, CHARLES B. MCCANTS, RALPH JOSEPH MCCrackEN, ADOLPH MEHLICH, RICHARD J. VOLK.

Assistant Professors: WILLIAM A. JACKSON, ROBERT E. MCCOLLUM, PRESTON HARDING REID, STERLING B. WEED.

The Department of Soils offers training leading to the degrees of Master of Science and Doctor of Philosophy in the following fields: Soil Chemistry, Soil Fertility, Soil Physics and Soil Genesis.

Excellent facilities are provided for soils graduate teaching and research in Williams Hall, a large modern building. Adequate office and laboratory space is assigned to each student. Numerous facilities available for use in carrying on a program of graduate study include special preparation rooms for soil and plants samples, cold storage space, radioactive and stable isotope laboratories, and service laboratories for routine soil and plant analyses. A departmental library is equipped with books, periodicals and bibliographic material relative to soils and related subjects. Seminars and analyses. A departmental library is equipped with books, periodicals and seminar room. Spacious greenhouses are situated at the rear of Williams Hall and are provided with benches, tables, lights and other essential equipment. Outdoor experiments in concrete frames, large tile, or small plots can be conducted in an area in close proximity to Williams Hall. Field experiments can be made on the seventeen research farms owned or operated by the state. These farms are located throughout North Carolina to include a wide variety of soil and climatic conditions needed for experiments in soils. One of the largest and best equipped soil testing laboratories in the United States is operated by the North Carolina Department of Agriculture in Raleigh. Special studies on the various problems of soil testing can be made in conjunction with this laboratory.

Strong supporting departments greatly increase the graduate student's opportunities for a broad and thorough training. Included among those departments in which graduate students in Soils work cooperatively or obtain instructions are Field Crops, Botany, Chemistry, Geology, Mathematics, Plant Pathology, Physics, and Statistics.

Many opportunities in reserach, teaching, extension and in commerical fields are available to well trained students in Soils. The recipients of advanced degrees in Soils from North Carolina State College are found in responsible positions throughout the world.

Courses for Graduates and Advanced Undergraduates

SOI 511. Soil Physics 4-0

Prerequisites: SOI 200 and PY 212.

Physical constitution and analysis; soil structure, soil water, soil air, and soil temperature in relation to plant growth. Mr. Lutz.

SOI 521. Soil Chemistry 4-0

Prerequisites: SOI 341, CH 212, and CH 532.

Chemical composition and properties of soil, particularly concerning clay mineralogy, chemical processes of weathering, and chemical properties of clays. The laboratory is concerned with procedures for the separation and identification of soil constituents and studies of certain fundamental properties of clay systems. Mr. Weed.

SOI 522. Soil Chemistry (Biochemical) 0-4

Prerequisites: SOI 341, CH 212, CH 532.

Theoretical basis for the application of stable isotopes and mass spectrometry to soil-plant research. Surface chemistry of inorganic and organic soil colloids. Physicochemical concepts of ion exchange phenomena in soils and the dynamic equilibrium associated with nutrient uptake by plant roots. Laboratory consists of exercises in mass spectrometry and ion exchange to illustrate fundamental principles. Mr. Volk.

SOI 532. Soil Microbiology 0-3

Prerequisites: SOI 200, BO 412, 421.

The more important microbiological processes that occur in soils; decomposition of organic materials, ammonification, nitrification and nitrogen fixation. Mr. Bartholomew.

SOI 551. Soil Morphology, Genesis and Classification 4-0

Prerequisites: SOI 200, CH 212, MIG 120.

Morphology; Study of concepts of soil horizons and soil profiles and chemical, physical and mineralogical parameters useful in characterizing them. Genesis: Critical study of soil forming factors and processes. Classification: Critical evaluation of historical development and present concepts of soil taxonomy with particular reference to Great Soil Groups as well as discussion of logical basis of soil classification. Laboratory comprises field trips for study of soil profiles representative of Great Soil Groups present in North Carolina, and a number of exercises illustrating methods of study of soil Morphology. Mr. McCracken.

SOI 570. Special Problems Credits by Arrangement

Prerequisites: SOI 200, CH 212.

Special problem in various phases of Soils. Problems may be selected or will be assigned. Emphasis will be placed on review of recent and current research. Graduate Staff.

Courses for Graduates Only*

SOI 622. Advanced Soil Chemistry Semester by Arrangement

Prerequisites: SOI 521, 522.

A critical examination of current ideas in Soil Chemistry and related fields. Topics will include ion exchange, ionic and molecular absorption, electrokinetics, relations between the structures of mineral and organic soil components and their chemical and physical properties.

Mr. Coleman.

SOI 632. Advanced Soil Microbiology Semester by Arrangement

Prerequisites: SOI 522, 532, CH 421, 422. Max. 4

A critical examination of information relating to the nature and value of microbiological processes in soil. Segments of the course will be devoted to: (1) Formation, chemical composition and biological stability of soil organic matter; (2) Biological transformations of nitrogen; (3) Function of organic matter in soil; (4) Factors influencing nitrogen fixation; and (5) Plant-microbial relationships.

Mr. Bartholomew.

SOI 642. Advanced Soil Fertility 0-3

Prerequisites: SOI 511, 521, 522.

Soil conditions affecting crop growth; the chemistry of soil and plant interrelationships, theoretical and applied aspects of fertilizer usage in relation to plant nutrition.

Mr. Fitts.

SOI 651. Advanced Soil Genesis and Classification 2-3, By Arrangement

Prerequisites: SOI 511, 521, 551. f or s

A critical study of current theories and concepts in soil genesis and morphology; detailed study of soil taxonomy. Topics include weathering and clay mineral genesis as related to soil morphology and genesis, functional analyses of soil genesis, properties of and processes responsible for soil profiles formed under various sets of soil forming factors, classification theory and logic as applied to soil classification, structure of soil classification schemes. Any of these topics may be emphasized at the expense of the others according to interests of students.

Mr. McCracken.

SOI 680. Seminar 1-1

Prerequisite: Graduate standing in Soils.

Scientific articles, progress reports in research, and special problems of interest to agronomists reviewed and discussed.

A maximum of two credits allowed towards the master's degree but any number towards the doctorate.

Graduate Staff.

SOI 690. Research Credit by arrangement

Prerequisite: Graduate standing in Soils.

A maximum of six credits is allowed toward the master's degree, but any number toward the doctorate.

Graduate Staff.

* Students are expected to consult the instructor before registration.

DEPARTMENT OF STATISTICS (EXPERIMENTAL)

Graduate Faculty

Professors: JACKSON ASHCRAFT RIGNEY, Head, RICHARD LOREE ANDERSON, COLUMBUS CLARK COCKERHAM, GERTRUDE MARY COX, ALVA LEROY FINKNER, ROBERT JOHN HADER, HENRY LAURENCE LUCAS, JR., DAVID DICKENSON MASON, ROBERT JAMES MONROE, HAROLD FRANK ROBINSON.

Associate Professors: ARNOLD HERBERT EDWARD GRANDAGE, FRANCIS EDWARD McVAY.

Assistant Professors: MELVIN WINSOR CARTER, JACK FLEISCHER, WILLIAM WESLEY GARRY SMART, JR.

The Department of Experimental Statistics offers work leading to the Master of Science and Doctor of Philosophy degrees. There is a working arrangement with the Department of Biostatistics in the University's School of Public Health at Chapel Hill, whereby their graduate students can major in Experimental Statistics and minor in the Division of Health Affairs. The Department of Experimental Statistics maintains a close liaison with the Department of (Mathematical) Statistics at Chapel Hill in order to strengthen the offerings in statistical theory. (See U. N. C. courses listed below.) Introductory courses of these two departments are coordinated so that it is easy for a beginning statistics graduate student to transfer from one institution of the Consolidated University to another. Both departments are affiliated with the Institute of Statistics (See page 25).

The Department has at least one staff member who consults with researchers in each of the following fields and who conducts his own research on statistical problems which are encountered: the various agricultural sciences, quantitative genetics, industry and engineering, physical sciences and social sciences. In addition there is active research in the general fields of experimental design and sample surveys. A graduate student who majors in Experimental Statistics may specialize in any one of these fields of interest with his minor in the associated department; or with a strong mathematical background he may prefer to minor in mathematics or mathematical statistics. For the graduate student who wishes to minor in statistics, the Department has developed a curriculum tailored to his needs. Many employers are offering added inducements for research personnel who have such a minor. The Department maintains close cooperation with other graduate departments in order to provide the type of courses needed for their students and to provide a staff to participate in their graduate programs.

In addition to its consulting services, the Department also provides a computing service for the Agricultural Experiment Station and for other research departments on the campus and in the State. It furnishes several federal agencies and private concerns with research and consulting services on a contract basis. All of this work supplies a wealth of live problems on which graduate students acquire experience and maturity.

The Department of Experimental Statistics is located in Patterson Hall, adjacent to the new D. H. Hill Library, which has copies of most important statistical books and periodicals. The reprint files of several staff members are available for the use of graduate students. A fully equipped IBM

Laboratory, including an IBM 650 electronic digital computer, is maintained for research and instruction, and automatic desk calculators are also available.

The Department has approximately 20 graduate assistantships at stipends adjusted to the previous training and experience of the recipients.

Most fields of research, development, production and distribution are seeking persons trained in statistical theory and methods. The demand is equally strong from universities, agricultural and engineering experimental stations, national defense agencies, other federal agencies, and a wide variety of industrial concerns. There is a need for experimental statisticians with the master's degree as well as for those with the doctorate. With so few institutions now providing the type of statistical training available at North Carolina State College, there is no hope of satisfying this demand for years to come.

At the request of the Southern Regional Education Board's Advisory Commission on Statistics, Virginia Polytechnic Institute, Oklahoma State University, the University of Florida, and North Carolina State College have joined in a continuing program of graduate summer sessions in statistics, held at the four institutions in rotation. In 1960 the host institution is the University of Florida, followed by Virginia Polytechnic Institute and Oklahoma State University. Each of the sponsoring institutions will accept the credits earned by students in the summer sessions as residence credit. The courses are arranged to provide consecutive work in successive summers. Information regarding these courses may be obtained from any of the cooperating statistical departments or the Deans of the Graduate Schools.

Courses for Graduates and Advanced Undergraduates

***ST 511. Experimental Statistics for Biological Sciences, I** 4 or 4
Prerequisites: ST 311 or graduate standing.

Basic concepts of statistical models and use of samples; variation, statistical measures, distributions, tests of significance, analysis of variance and elementary experimental design, regression and correlation, Chi-square.
Messrs. Monroe, Carter.

***ST 512. Experimental Statistics for Biological Sciences, II** 0-3
Prerequisite: ST 511.

Covariance, multiple regression, factorial experiments, individual degrees of freedom, incomplete block designs, experiments repeated over space and time.
Mr. Mason.

ST 513. Experimental Statistics for Social Sciences, I 4-0
Prerequisite: ST 311 or graduate standing.

Basic concepts in collection and analysis of data. Variability of sample data, distributions, confidence limits, Chi-square, t-test, analysis of variance, regression, correlation, analytic and descriptive surveys, experimental designs, index numbers.
Mr. McVay.

†ST 514. Experimental Statistics for Social Sciences, II 0-3
Prerequisite: ST 513.

Extension of basic concepts of experimental statistics to social surveys

*Offered in special summer sessions at the University of Florida (1960), and Virginia Polytechnic Institute (1961).

†Offered in special summer session at University of Florida (1960).

and experiments. Sampling from finite populations; sampling systems, unrestricted, stratified and multistage; random and systematic selection with varying probabilities; methods of estimation; analysis of variance with multiple classifications; covariance; multiple regression; polynomials.

Mr. Fleischer.

ST 515, 516. Experimental Statistics for Engineers 3 or 4-3

Prerequisite: ST 361 or graduate standing.

General statistical concepts and techniques useful to research workers in engineering, textiles, wood technology, etc. Probability, distributions, measurement of precision, simple and multiple regression, tests of significance, analysis of variance, enumeration data, sensitivity data, life testing experiments and experimental design.

One credit optional laboratory available first semester only.

Mr. Hader.

***ST 521, 522. Basic Statistical Theory** 4-4

Prerequisites: ST 311 or graduate standing and undergraduate calculus.

Probability, frequency distributions and moments; sampling distributions; introductory theory of point and interval estimation; parametric and non-parametric tests of hypotheses; theory of least squares; multiple regression; analysis of variance and covariance, variance components.

This course contains the theory needed in all advanced courses in statistical analysis and some of the fundamentals for advanced theory courses.

Graduate Staff.

ST 591. Special Problems 1 to 3 - 1 to 3

Development of techniques for specialized cases, particularly in connection with thesis and practical consulting problems. Graduate Staff.

U.N.C. ST 111. Methods of Mathematical Statistics, I. 3-0

Prerequisite: Advanced Calculus

Introductory treatment of special mathematical techniques of particular importance in probability and statistics, including topics from combinatorial mathematics, Fourier and LaPlace transforms, contour integration, special inequalities and finite differences.

Mr. Smith.

U.N.C. ST 131. Elementary Probability 3-0

Prerequisite: Advanced Calculus

Logical foundations and axiomatic treatment of probability, conditional probability, additive and multiplicative laws, Bayes' theorem and inverse probability, binomial and Poisson distributions, moments and moment generating functions, law of large numbers and central limit theorem, convolution of distributions.

Graduate Staff.

U.N.C. ST 132. Intermediate Probability 0-3

Prerequisite: U.N.C. ST 131 or 134.

Laws of large numbers, characteristic functions, and central limit theorems. Elements of stochastic processes and their applications, including random walks, Markov chains, recurrent events, Brownian motion, and elementary queuing theory.

Mr. Smith

*Offered in special summer sessions at the University of Florida (1960), and Virginia Polytechnic Institute (1961).

U.N.C. ST 133. Least Squares and Time Series 0-3

Prerequisites: U.N.C. ST 134 and Matrix Algebra

The classical method of least squares with modern improvements and developments, interpretations of the results in terms of probability, applications to social and to natural sciences, the problem of observations ordered in time, correlation and regression of time series, seasonal variation and secular trends, methods of correcting for lack of independence and of avoiding fallacies.

U.N.C. ST 134. Statistical Theory I 5-0

Prerequisite: Advanced Calculus

Relative-frequency and axiomatic definitions of probability. The concept of a random sample. Additive and multiplicative laws. Univariate and multivariate, marginal and conditional distributions. Discrete and continuous cases. Moments, cumulants, generating functions. Transformation of variables. Introduction to tests of simple hypotheses and interval estimates. Model building. Special distributions: binomial, Poisson normal, etc. Law of large numbers. Central limit theorem. Order statistics. Multinomial distribution theory. Chi-square. Graduate Staff.

U.N.C. ST 135. Statistical Theory II 0-3

Prerequisite: U.N.C. ST 134.

Distributions of functions of random normal samples. F and t distributions. Point estimation. Properties of estimators, maximum likelihood. Information. Cramér-Rao inequality. Interval estimation. Neyman-Pearson tests of hypotheses. Likelihood ratio tests. Contingency tables. Chi-square tests of goodness of fit. Elements of decision theory and sequential and non-parametric inferences.

U.N.C. ST 144. Correlation, Contingency, and Chi Tests 0-3

Prerequisite: U.N.C. ST 135; Corequisite: Matrix Algebra

Elements of the theory of testing composite hypotheses. Multivariate normal populations, total, partial and multiple correlations. Singular multivariate distributions. Tests of independence, homogeneity, and goodness of fit. Contingency tables; exact tests for independence and the Chi approximation. Many-dimensional contingency tests. Mr. Hotelling.

U.N.C. ST 150. Analysis of Variance with Application to Experimental Designs 0-3

Prerequisite: Matrix Algebra; Corequisite: U.N.C. ST 135.

Unified mathematical theory for the analysis of data from experimental designs. Applications to lattice designs, balanced and partially balanced incomplete block designs, Latin and Youden squares; modification for missing plots; intra-block and inter-block analysis; split plot and factorial designs; analysis of factorial designs in the case of total or partial confounding; use of concomitant information; analysis of covariance with the general linear model; analysis of multiple classified data with unequal numbers in different cells; general theory of components of variance including mixed models; principles guiding the selection of a design.

Mr. Bose.

- U.N.C. ST 182. Mathematical Economics** 3-0
 Prerequisite: Advanced Calculus; co-requisite: Matrix Algebra.
 Perfect and imperfect competition, monopoly, utility vs. ranking of preferences, relations between commodities, general equilibrium, effects of taxes and controls of various kinds, index numbers.
Offered in fall of 1960-1961 and alternate years. Mr. Hotelling.
- U.N.C. ST 183. Advanced Mathematical Economics** 0-3
 Prerequisites: U.N.C. ST 182 and Differential Equations.
 Dynamic variations in the economy; calculus of variations and stochastic process theory with applications to economic problems; valuation, depreciation, and depletion; most profitable rates of exploitation of mineral and biological resources.
Offered in spring of 1960-1961 and alternate years. Mr. Hotelling.
- U.N.C. ST 197. Population Statistics.** 0-3
 Prerequisite: Permission of instructor.
 Training in techniques for quantitative research with population data. Composition characteristics, population estimates, computation and standardization of birth and death rates, construction and application of life tables, measurement of migration. Graduate Staff.

Courses for Graduates Only

- ST 611, 612. Intermediate Statistical Theory** 3-3
 Prerequisites: ST 522, Advanced Calculus and Matrix Theory.
 This course will provide the additional theory, above that of ST 521-522, needed for advanced theory courses. Many of the topics of ST 521-522 will be developed more rigorously, and more attention will be paid to mathematical aspects. Advanced probability theory; central limit theorem, law of large numbers, bivariate normal distributions, convergence theorems. Theory of estimation; method of maximum likelihood, efficient estimates, simultaneous confidence regions; general theory of tests of hypotheses, general linear hypothesis, sequential tests of hypotheses, distribution-free methods. Graduate Staff.
- ST 621. Statistics in Animal Science** 3-0
 Prerequisite: ST 512.
 Sources and magnitudes of errors in experiments with animals, experimental designs and methods of analysis adapted to specific types of animal research, relative efficiency of alternate designs, amount of data required for specified accuracy, student reports on selected topics.
Offered in fall of 1961-62 and alternate years. Mr. Lucas.
- ST 622. Principles of Biological Assays**
 (See AI 622.)
- ST 623. Statistics in Plant Science** 3-0
 Prerequisite: ST 512.
 Principles and techniques of planning, establishing, and executing field and greenhouse experiments. Size, shape and orientation of plots; border effects; selection of experimental material; estimation of size of experi-

ments for specified accuracy; scoring and subjective tests; subsampling plots and yields for laboratory analysis. Mr. Mason.

ST 626. Statistical Concepts in Genetics 0-3

Prerequisites: Genetics 512, and ST 512 unless taken concurrently.

Factors bearing on rates of change in population means and variances, with special reference to cultivated plants and domestic animals; selection, inbreeding, magnitude and nature of genotypic and non-genotypic variability; experimental and statistical approaches in the analysis of quantitative inheritance. Mr. Cockerham.

ST 631. Theory of Sampling Applied to Survey Design 3-0

Prerequisite: ST 512 or 514 or 516.

Basic theory of sampling from a finite population. Confidence limits and estimation of optimum sample size, comparison of different sample designs, methods and probabilities for selection and methods of estimation, choice of a sampling unit, double sampling, matched samples.

Mr. Finkner.

ST 641. (RS 641) Statistics in Sociology 3-0

Prerequisite: ST 513.

The application of statistical methods in sociological research. Emphasis on selecting appropriate models, instruments and techniques for the more frequently encountered problems and forms of data. Mr. Hamilton.

ST 651. (AGC 651). Econometric Methods I. 0-3

Prerequisites: ST 514, ST 521, and AGC 642.

Decision-making under uncertainty; stochastic elements in economic theories; problems of model construction; special techniques for analyzing simultaneous economic relations. Graduate Staff.

ST 652. (AGC 652). Econometric Methods II 3-0

Prerequisites: ST 522, and AGC 641.

Basic concepts of estimation and tests of significance as applied to economic data; empirical sampling methods; non-parametric methods; sequential testing; extension of least squares methods to research in economics; production surfaces; special topics in variance components and mixed models; use of experimental designs in economic research; elements of multivariate analysis; techniques for analysis of time series.

Mr. Anderson.

ST 661. Advanced Special Problems 1 to 3—1 to 3

Prerequisite: ST 522.

Any new advance in the field of statistics which can be presented in lecture series as unique opportunities arise.

Graduate Faculty, Visiting Professors.

ST 671. Advanced Statistical Analysis 3-0

Prerequisites: ST 512, ST 522.

General computational methods for linear regression, non-orthogonal data, carryover effects, orthogonal polynomials, response surfaces, non-

linear systems, variance components for orthogonal and non-orthogonal data. Mr. Anderson.

ST 672. Special Advanced Topics in Statistical Analysis 0-3
Prerequisite: ST 671.

Regression analysis with errors in both variables, transformations, enumeration data, discriminant functions, heterogeneous errors, non-parametric analysis. Mr. Monroe.

ST 674. Advanced Topics in Construction and Analysis of Experimental Designs 0-3

Prerequisite: ST 512 and ST 522.

Inter-block analysis of incomplete blocks designs, partially balanced designs, confounding, data collected at several places and times, multiple factor designs, change-over trials, analysis of groups of means.

Miss Cox.

ST 681. Seminar 1-1

A maximum of two credits is allowed toward the master's degree, but any number toward the doctorate. Graduate Staff.

ST 691. Research Credits by arrangement

A maximum of nine credits is allowed toward the master's degree; no limitation on credits in doctorate programs. Graduate Staff.

U.N.C. ST 200. Applied Multivariate Analysis 3-0

Prerequisite: U.N.C. ST 135.

The general multivariate model for experimental work; relations between multiple regression, analysis of variance and multivariate analysis; factor analysis; the generalized variance; the generalized Student ratio; intra-class correlations; testing compound symmetry between two sample covariance matrices; scale analysis; canonical correlation, testing for the rank of a correlation matrix.

Offered in fall of 1960-61 and alternate years.

Mr. Nicholson.

U.N.C. ST 202. Methods of Operations Research 3-0

Prerequisite: U.N.C. ST 135.

Linear programming, theory of games, techniques for analyzing waiting lines and queues; applied probability; recent developments, applications of results to specific problems; case studies.

Mr. Nicholson.

U.N.C. ST 204. Selected Techniques of Approximation 3-0

Prerequisite: Advanced Calculus.

The methods of steepest descent and other methods of approximating integrals with special attention to integrals occurring in probability and statistics; asymptotic series; large-sample approximations; orthogonal polynomials and their applications to numerical quadrature, interpolation and moment problems.

Offered in fall of 1961-62 and alternate years.

Mr. Hotelling.

U.N.C. ST 210. Design and Analysis of Experiments 3-0

Prerequisites: ST 512 and U.N.C. ST 150.

The principles of the design and analysis of experiments with applica-

tions, randomization, replication, local control. Randomized blocks, Latin and Graeco-Latin squares, factorial experiments. Confounding, fractional factorials, response surface designs, recent developments.

Graduate Staff.

U.N.C. ST 212. Methods of Mathematical Statistics, II. 0-3

Prerequisite: Advanced Calculus.

Measure and integration theory, with special reference to random variables, distribution functions, and probability measures, and including Fubini's Theorem, the Radon-Nikodym Theorem, conditional probability, conditional expectation, and modes of convergence.

Mr. Hall.

U.N.C. ST 220. Theory of Estimation and Hypothesis Testing 4-0

Prerequisites: U.N.C. ST 132, 135 and 212.

Sufficient statistics. Unbiased estimates with minimum variance. Properties of tests—power, similarity, unbiasedness, sampling economy, etc. Admissible, Bayes and minimax estimates and tests. Invariance. Large sample theory. Confidence sets. Multi-decision problems.

Mr. Hall.

U.N.C. ST 221. Sequential Analysis 2-0

Prerequisites: U.N.C. ST 132 and 135.

Estimation and testing when the sample size depends on the observations. Double sampling. Inverse sampling. Sequential probability ratio tests. Stochastic approximation methods.

Mr. Hoeffding.

U.N.C. ST 222. Nonparametric Inference 0-3

Prerequisites: U.N.C. ST 132, 135 and 212.

Estimation and testing when the functional form of the population distribution is unknown. Rank and sign tests, tests based on permutations of observations, power of nonparametric tests, optimum nonparametric tests and estimators, nonparametric confidence intervals and tolerance limits.

Mr. Hoeffding.

U.N.C. ST 231. Advanced Probability 3-0

Prerequisites: U.N.C. ST 132 and 212.

Advanced theoretic course, including: random variables and expectations, distributions and characteristic functions, infinitely divisible distributions, central limit theorems, laws of large numbers, and stable laws.

Offered in fall of 1960-61 and alternate years.

Mr. Smith.

U.N.C. ST 232. General Theory of Statistical Decision 0-3

Prerequisites: U.N.C. ST 135 and 212.

Selected topics in the general theory of statistical decisions, based on the work of Abraham Wald.

Offered in spring of 1960-61 and alternate years.

Mr. Hoeffding.

U.N.C. ST 235. Stochastic Processes 0-3

Prerequisites: U.N.C. ST 132 and 212.

Advanced theoretic course, including: separability of a process, processes with orthogonal random variables, Markov processes, martingales, and processes with independent increments.

Offered in spring of 1961-62 and alternate years.

Messrs. Smith and Hoeffding.

- U.N.C. ST 237. Time Series Analysis** 0-3
 Prerequisite: U.N.C. ST 133.
 Analysis of data involving trends, seasonal variations, cycles and serial correlations; periodograms and correlograms; exogenous and endogenous cycles; stochastic difference equations; tests for randomness; distributions of serial correlation coefficients; the sinusoidal limit theorem.
Offered in spring of 1961-62 and alternate years. Mr. Hotelling.
 3 or 3
- U.N.C. ST 251. Combinatorial Problems of the Design of Experiments**
 Prerequisites: U.N.C. ST 150 and 210.
 Application of methods of modern algebra and finite geometry to problems arising in the design of experiments. Construction of orthogonal sets of Latin squares, construction of balanced and partially balanced designs, proofs of non-existence of certain classes of designs, construction of confounded factorial designs, fractional replications, orthogonal arrays and multifactorial designs.
 Mr. Bose.
- U.N.C. ST 260. Multivariate Analysis** 3-0
 Prerequisites: U.N.C. ST 135 and Matrix Algebra.
 Tests and confidence intervals in multivariate analysis of variance, association between subsets of a multivariate normal set, the rank of a matrix, factor analysis.
 Mr. Roy.
- U.N.C. ST 261. Advanced Multivariate Analysis** 0-3
 Prerequisite: U.N.C. ST 260.
 Distribution problems connected with the tests and confidence intervals discussed in ST 260; the power functions of the tests and the shortness of the confidence intervals against different classes of alternatives; some applications, especially to problems in sociology, psychology and anthropology.
 Mr. Roy.
- U.N.C. ST 321-322. Special Problems** 3-3
 Statistical theory of multi-factor and multi-response experiments with responses not necessarily "normal."
 Mr. Roy.

SCHOOL OF TEXTILES

Professors: MALCOLM EUGENE CAMPBELL, Dean, CLARENCE MONROE ASBILL, JR., JOHN FRANCIS BOGDAN, KENNETH STODDARD CAMPBELL, ELLIOT BROWN GROVER, DAME SCOTT HAMBY, HARLEY Y. JENNINGS, EDWARD ANNE MURRAY, WILLIAM A. NEWELL, HENRY AMES RUTHERFORD, WILLIAM EDWARD SHINN, and BENJAMIN LINCOLN WHITTIER.

Visiting Professor: CHARLES F. GOLDTHWAIT.

Associate Professors: DAVID MARSHALL CATES, ARTHUR COURTNEY HAYES, JOSEPH ALEXANDER PORTER, JR.

Assistant Professor: ERNEST B. BERRY.

The School of Textiles offers two graduate degrees: Master of Science in Textile Technology and Master of Science in Textile Chemistry. The

graduate student in Textile Technology may carry on his major work in one of the following fields: Fiber and Yarn Technology, Knitting Technology, Synthetics, Fabric Development, or Quality Control.

An applicant for admission to the Graduate School for work in textiles must possess a Bachelor of Science degree in Textiles or its equivalent, in addition to satisfying the general requirements for admission.

The physical resources of the School of Textiles are at the disposal of our graduate students. Separate research laboratories for both physical and chemical investigations are provided for the use of graduate students and the specialized equipment of the Textile Research Department also is available for graduate research. The textile equipment and testing instruments available at the School of Textiles are of such quality and variety that almost any type of textile problem can be investigated thoroughly. A large and representative textile library is one of the important facilities available for graduate study.

The unprecedented development of synthetic fibers currently underway has opened a tremendous field for the textile scientist and technologist. Fiber producers need men trained to conduct systematic investigations which lead to product development and improvement.

Courses for Advanced Undergraduates

Fiber and Yarn Technology

TX 401. Yarn Manufacture IV

4 or 4

Prerequisite: TX 301.

Required of seniors in Yarn Manufacturing and General Textiles Options. Elective for others.

Refinements on yarn production, such as detailed studies of carding; production levels; comber types, settings, and quality aspects; modern drafting assemblies. Review of all yarn mill calculations. Production of novelty yarn, and special yarns such as voile, crepe. Special techniques and problems; types of winders; large package production, types of travelers and rings; operation schedules. Lab project in small groups.

Three 1-hour lectures and one 2-hour laboratory period per week.

Mr. Stuckey.

TX 402. Mill Technology

3 or 3

Prerequisite: TX 301.

Required of seniors in Yarn Manufacturing and Synthetics Options. Elective for others. Mill Layout: Layout of textile mill of cotton or synthetics type. Types of machines, numbers, and balance of equipment. Floor layout plans and process flow, speeds, productions, help layout, power and investment.

Three 1-hour lectures per week.

Messrs. Grover, Pardue.

TX 411. Wool Manufacture I

3 or 3

Prerequisite: TX 301.

Required of seniors in Yarn Manufacturing and General Textiles Options. Elective for others.

Raw materials used in wool and worsted trades; classification, structure, and characteristics of fibers, grading, sorting and mixing. Reclaimed wool and secondary raw materials. Lectures are supplemented by laboratory applications.

Two 1-hour lectures and one 2-hour laboratory period per week.

Mr. Pardue.

TX 424. Development Project

0-2

Prerequisite: TX 327 and ST 361 or equivalent.

Required of seniors in Quality Control Option.

Studies are conducted independently on assigned problems, and seminars are held on applications and administration of testing, quality control and development. Studies and discussion of budgeting and evaluation of priority and progress. Current technical developments are discussed. Results of project to be written in form of a technical report from a control and development laboratory.

One 4-hour laboratory period per week.

Mr. D. S. Hamby and Staff.

TX 431. Synthetics I

2 or 2

Prerequisite: TX 281.

Required of seniors in General Textiles, Weaving and Designing, and Yarn Manufacturing options.

A general course including: textile processing of continuous filament synthetic yarns

in the yarn producing plants; preparation of yarns for weaving and knitting including crepe, voile and hosiery yarns; the application of synthetic yarns for use as industrial yarns and fabrics; also, calculations involving the denier system and production. No credit allowed for students majoring in synthetics.

Two 1-hour lectures per week.

Mr. Wiggins.

TX 433. Synthetics II

4-0

Prerequisite: TX 281 and senior standing.

Required of seniors in Synthetics Option.

An advanced study of the physical properties and the relation of physical properties to the processing characteristics and end product performances of the synthetic fibers. A study of the influence of twist on physical properties of filament yarns; comprehensive studies of the processing of sized and unsized filament yarn as encountered in the throwing industry and in preparation for knitting and weaving. A study of the industrial uses of synthetic fibers and the requirements of such uses.

Three 1-hour lectures and one 2-hour laboratory period per week.

Messrs. Hamby, Wiggins.

TX 435. Synthetic Fiber Processing

4 or 4

Prerequisites: TX 301.

Required of seniors in Yarn Manufacturing and Synthetic Options.

Elective for others.

Studies of the contributions of individual fibers to the entire blend covering both the man-made as well as natural fibers. Processing of man-made fibers into spun yarn and fabric, particularly on the cotton system. The processing of man-made fibers by new methods, such as by direct spinning and the Pacific Converter. Studies of the modification of machines for processing synthetic fibers alone or in blend with other fibers.

Three 1-hour lectures and one 2-hour laboratory period per week.

Messrs. Grover, Hamby, Pardue.

Knitting Technology

TX 441. Flat Knitting

3-0

Prerequisite: TX 341.

Required of seniors in Knitting Technology Option. Elective for others.

A study of the leading types of flat knitting machines including warp knitting machines, design possibilities, and fabric adaptability.

Two 1-hour lectures and one 2-hour laboratory period per week.

Mr. Shinn.

TX 443. Knitting Mechanics

3-0

Required of seniors in Knitting Technology Option. Elective for others.

Mathematics and mechanics of flat and rib knitting. Inter-relation of yarn number, yarn diameter, gauge, cut, stitch, length, fabric structure and weight; proportions of yarns in multiple-thread work; production problems, etc.

Two 1-hour lectures and one 2-hour laboratory period per week.

Mr. Shinn.

TX 444. Garment Manufacture

0-3

Required of seniors in Knitting Technology Option. Elective for others.

A study of circular latch needle and spring needle machines for knit fabric production styling, cutting and seaming of the basic garment types for underwear and outerwear; standard seam types; high-speed sewing machines.

Two 1-hour lectures and one 2-hour laboratory period per week.

Messrs. Shinn, Lewis.

TX 445. Full-fashioned Hosiery Manufacture

0-2

TX 447,448. Knitting Laboratory II

2-2

Required of seniors in Knitting Technology Option. Elective for others.

Mechanics of the full-fashioned hosiery machine including practical training in its adjustment and operation. Attention is given to yarn preparation, knitting, inspection, finishing and packaging hosiery.

One 4-hour laboratory period per week each semester.

Mr. Shinn.

TX 449. Tricot Knitting

0-3

Required of seniors in Knitting Technology Option. Elective for others.

A study of basic types of tricot knitting machines with emphasis on mechanisms and fabrics. Attention is given to warp preparation methods applicable to the tricot machine, the characteristics of yarns made from natural and synthetic fibers as they affect processing into warp knitted fabrics, machine settings for proper qualities and ratios; economics of warp knitting, and end uses. Attention is given to fabric design and analysis.

Two 1-hour lectures and one 2-hour laboratory per week.

Mr. Shinn.

Fabric Development

TX 451. Weaving Laboratory IV

1 or 1

Prerequisite: TX 351 and TX 361.

Required of seniors in General Textiles and Weaving and Designing Options. Elective for others.

Operations and fixing of dobby, pick and pick and jacquard looms; preparation of warps to weave rayon, wool and fine cotton fabrics; building of box, dobby and multiplier chains.

- One 2-hour laboratory period per week. Messrs. Moser, Berry. 0-2
TX 452. Weaving Technology
 Prerequisite: TX 451.
 Required of seniors in Weaving and Designing Option.
 Continuation of Tex. 451 with special emphasis upon making original designs for dobby fabrics, preparing the warps and weaving the fabrics.
 One 4-hour laboratory period per week. Messrs. Moser, Berry.
- TX 461. Design IV** 3-0
 Prerequisite: TX 361.
 Required of seniors in General Textiles and Weaving and Designing Options. Elective for others.
 A details study of the design and weave of complicated fabrics such as double cloth, corduroy, velveteen, crepe and intricate figured designs, matelasse, velvet and frieze.
 Analyzing samples of cotton, wool, worsted, linen, rayon and silk fabrics for size of yarns, ends and picks per inch, weight of warp and filling, so as to accurately reproduce samples analyzed; obtaining design drawing in draft, chain, and reed plan for fancy fabrics, such as stripes, checks, extra warp and extra filling figures, leno fabrics, jacquard fabrics, draperies.
 Two 1-hour lectures and one 2-hour laboratory period per week. Mr. Berry.
- TX 471. Development of Woven Designs** 2 or 2
 Prerequisite: TX 361.
 Elective.
 A study of the factors which determine the quality, style and color of fabrics, including the design specifications and production calculations necessary for the translation of design ideas into woven textiles.
 Two 1-hour lectures per week. Mr. Whittier and Staff
- TX 472. Fabric Analytics** 2-2
 Prerequisite: TX 361.
 A supplementary course in fabric structure to demonstrate how fabrics can be designed to meet specific requirements for utility and aesthetic value. The methods and calculations involved in predetermining weight, cast, texture, strength extensibility, thickness and other important properties of fabrics are explained, using actual cases of consumer problems as examples.
 Two 1-hour lectures per week. Mr. Whittier.
- TX 473. Fabric Characteristics** 2 or 2
 Prerequisite: TX 361.
 Elective.
 A study of the identification, classification and utilization of woven fabrics and how these are affected by various properties such as geometry, weave, and finish. Actual inspection of a wide range of fabrics with emphasis on a study of defects and their influence on quality will be included in the laboratory work.
 One 1-hour lecture and one 2-hour laboratory period per week. Mr. Whittier.

Textile Chemistry

- TC 403, 404. Textile Chemistry IV** 4-4
 Prerequisite: TC 304.
 Required of seniors in Textile Chemistry.
 A continuation of TC 303 and 304 with special emphasis on modern dyeing methods. Laboratory exercises and use of pilot and mill-scale equipment of many types in dyeing all important fibers and fiber mixtures. Selected topics of importance to the textile chemist with special attention to current technological advances in the field. Visits to mills selected to cover a wide variety of processing techniques.
 Two 1-hour lectures and one 4-hour laboratory per week. Mr. Campbell.
- TC 411. Textile Chemical Analysis I** 3 or 3
 Prerequisite: Chem. 211.
 Elective for students in Textile Chemistry.
 Analysis and evaluation of textile chemicals and related materials such as water, soap, wetting agents, synthetic detergents, bleaching and stripping agents, and finishing compounds. Identification and quantitative determination of materials employed in several categories of textile wet processing such as sizes, surface-active agents, dyestuffs and finishes.
 One 1-hour lecture and one 4-hour laboratory per week. Messrs. Rutherford, Campbell.
- TC 412. Textile Chemical Analysis II** 3 or 3
 Prerequisites: Chem. 211 and TC 304.
 Elective for students in Textile Chemistry.
 Analysis of textile materials involving specialized instruments and techniques such as spectrophotometry, pH measurements, electrometric titration, viscometry, etc.
 One 1-hour lecture and two 2-hour laboratories per week. Messrs. Rutherford, Campbell.
- TC 421. Fabric Finishing I** 2 or 2
 Prerequisite: TC 201.
 Required of seniors in Synthetics option. Elective for others, except not required nor elective for students in Textile Chemistry.

A general course in fabric finishing designed for students not majoring in Textile Chemistry. Emphasis placed on finishes used on garment-type fabrics, including stabilization finishes, water repellency, crease resistance, moth and mildew proofing, fire-proofing, etc. Emphasis on chemistry of finishes varied to fit requirements of students.

Two 1-hour lectures per week.

Messrs. Hayes, Rutherford.

TC 423. Fabric Finishing II

3-0

Prerequisite: TC 304.

Required of seniors in Textile Chemistry.

A study of the compounds used in the finishing of fabrics, and of the methods used in laboratory development and plant application of finishing compounds. Studies of the methods of evaluation of finishes are included in the laboratory work.

One 1-hour lecture and one 4-hour laboratory period per week.

Mr. Campbell.

TC 431. Textile Printing

0-3

Prerequisite: TC 304.

Required of students in Textile Chemistry.

Fundamentals of textile printing with major emphasis on modern roller printing methods; design of printing machines, preparation of cloth for printing, formulation and properties of printing pastes, application techniques for all important types of dyestuff, styles of printing, and ageing and aftertreating procedures.

One 1-hour lecture and one 4-hour laboratory period per week.

Mr. Campbell.

General Textile Courses

TX 483. Textile Cost Methods

2 or 2

Prerequisites: TX 301 and TX 361.

Required of seniors in Textiles except those in Management Option.

A survey of cost methods applicable to textile mills with emphasis on calculations, the preparation of cost reports, and their use in cost control.

Two 1-hour lectures per week.

Mr. Shinn.

TX 484. Mill Organization

0-3

Prerequisites: TX 301 and senior standing.

Required of seniors in Textiles.

Economic aspects of mill practices in buying cotton including cotton hedging techniques, price support programs, and mill rules governing buying; inventory methods; textile factoring; planning and scheduling of manufacturing contracts; analysis of manufacturing organizations based on processes and equipment.

Courses for Graduates and Advanced Undergraduates

FIBER AND YARN TECHNOLOGY

TX 501. Yarn Technology Seminar

2 or 2

Prerequisite: X 401 or equivalent and consent of instructor.

Elective

Lecture and discussion periods are designed for students who are particularly interested in the yarn manufacturing aspects of the textile industry. Subject matter will include such various aspects as training methods, safety programs, modern mill design, specialized techniques in setting rates, employee relations, and developments that arise from technical meetings.

Two 1-hour lectures per week.

Mr. Grover and Graduate Staff.

TX 521. Testing and Quality Control

4-0

Prerequisite: TX 327.

Required of students in Quality Control option. Elective for others.

Testing of natural and man-made fibers and of yarns and fabrics with emphasis on advanced testing techniques. Consideration of quality control programs, including "defect preventive" methods, pin-pointing of troubles, and the relationship between the quality control department and operating divisions. Technical report writing, literature research, and study of military specifications and U. S. Government standards as CCC-T-191-b. Attendance at technical meetings such as The Fiber Society, Amer-

ican Society for Testing Materials, American Society for Quality Control is encouraged. Messrs. Hamby, Stuckey.

Two 1-hour lectures and one 4-hour laboratory period per week.

TX 522. Textile Testing III

0-4

Prerequisite: TX 521, or graduate standing with approval of instructor.

Required of students in Quality Control Option. Elective for others.

Mechanics of textile fabrics, with emphasis on the application of engineering criteria to laboratory evaluation of natural and man-made fibrous materials. Stress-strain relationships, modifications due to impact, torsional properties, thermoplastic-material degradation, permeability to gases and liquids, theory of induced wear with influence of abrasion. Influence on fabric properties resulting from blending of fibers, and modification of properties by varying fiber distribution. Specialized techniques of controlling attributes and variables of fabric quality.

Two 1-hour lectures and one 4-hour laboratory period per week.

Messrs. Hamby, Stuckey.

TX 525. Advanced Textile Microscopy

2 or 2

Prerequisite: TX 327.

Elective.

Experiments, lectures and demonstrations in more advanced techniques of textile microscopy. Detailed studies of structures of fibers covered in lecture series, supplemented by experiments on lecture topics. Detailed study of all types of microscopes and their uses in textiles. Preparation of slides for photography. Uses of photomicrographic equipment.

Lectures and laboratories arranged.

Mr. Stuckey.

FABRIC DEVELOPMENT

TX 551. Complex Woven Textile Structures

0-3

Prerequisites: TX 451, TX 461.

Elective.

Consideration of design factors, operational problems, and fabric geometry peculiar to complex woven textile structures such as terry cloth, plush, ability for specific end uses.

Two 1-hour lectures and one 2-hour laboratory per week. Mr. Berry.

TX 561. Special Weave Formations

0-2

Prerequisite: TX 461.

Required of Seniors in Weaving and Designing Option. Elective for others.

The development of design specifications for selected complex fabrics and a study of the geometrical and aesthetic factors influencing their suit- and carpeting.

Two 1-hour lectures per week.

Mr. Berry.

TX 562. Jacquard Design and Weaving

0-3

Prerequisite: TX 361.

Required of Seniors in Weaving and Designing Option. Elective for others.

The application of punched card techniques to the design and manufac-

ture of certain fabrics having intricate decorative patterns and special surface characteristics.

Two 1-hour lectures and one 2-hour laboratory per week.

Mr. Berry.

TEXTILE CHEMISTRY

TC 501. Seminar in Textile Chemistry 0-2

Prerequisite: TC 403.

Elective for Textile Chemistry students.

The course is designed to familiarize the student with the principal sources of textile chemical literature and to emphasize the importance of keeping abreast of developments in the field of textile chemistry. Particular attention is paid to the fundamentals of technical writing. Reports.

Lectures arranged.

Mr. Campbell, Graduate Staff.

TC 511. Chemistry of Fibers 3-0

Prerequisite: CH 422.

Required of seniors in Textile Chemistry.

A lecture course emphasizing the theory of fiber structure; the relationship between the chemical structure and physical properties of natural and synthetic fibers; the nature of the chemical reactions that produce degradation of fibers; the production of synthetic fibers.

Three 1-hour lectures per week.

Mr. Rutherford.

TC 512 (CH 512). Chemistry of High Polymers 0-3

Prerequisites: CH 341 or CH 531.

Principles of polymer synthesis including condensation, addition, and ionic polymerization; techniques of bulk, solution, and emulsion polymerization; physical-chemical studies including preparation, solution properties, and size, structure, and mechanical properties of macro-molecules.

Mr. Cates.

TC 521. Textile Chemical Analysis III 3 or 3

Prerequisite: TC 421.

Elective for all textile students except those majoring in Textile Chemistry; no credit allowed for those majoring in Textile Chemistry.

The work includes the chemical identification of fibers, the qualitative and quantitative analysis of fiber blends by chemical means, and the evaluation techniques for dyed and finished materials.

Lectures and laboratories arranged.

Graduate Staff.

GENERAL TEXTILES

TX 581. Instrumentation and Control 3 or 3

Prerequisite: PY 212.

Required of all seniors in Textiles and Textile Chemistry.

A lecture series with coordinated laboratory exercises designed to familiarize the student with the theory and application of instruments and control apparatus that he will find in the modern textile plant.

The studies cover the measurement and control of temperature, humidity,

pressure, flow and liquid level, and the application of control apparatus to chemical processes and physical finishing of textile products.

Two 1-hour lectures and one 2-hour laboratory period per week.

Mr. Asbill.

Courses for Graduates Only

TX 601, 602. Yarn Manufacture 3-3

Prerequisites: TX 401 or equivalent.

Studies of advanced techniques in textile production; the technological aspects of fiber properties in relation to processing; studies of research findings and application of these to processing equipment.

Messrs. Grover, Hamby.

TX 621. Textile Testing IV 2 or 2

Prerequisites: TX 522 or equivalent.

Design of textile laboratories, including conditioning equipment and instruments required for specific needs; performance of tests and analysis of data on industrial problems; specialized physical tests; inter-laboratory tests and analysis; study of A.S.T.M. specifications and work on task groups for the A.S.T.M. Society.

Mr. Hamby.

TX 631. Synthetics IV 0-2

Prerequisites: TX 433 or equivalent.

Setting up of an assigned project on problems peculiar to the processing of continuous filament yarns, particularly in the initial preparatory stages of processing, including sizing, twisting, winding, and associated problems.

Mr. Hamby.

TX 641, 642. Advanced Knitting Systems and Mechanisms. 3-3

Prerequisites: TX 441 or equivalent.

A critical study of inventions which have contributed to the development of the modern knitting industry; knitting needles and their adaptation for specific uses; means for mounting them for individual and en masse operation; construction and functioning of cooperating elements including sliders, jacks, sinkers, dividers, pressing elements, narrowing and widening points, welting mechanisms; yarn feeding elements, fabrics tensioning and draw-off motions, regulating mechanisms; timing and control chains and cams. Use will be made of patent literature which represent important developments in the knitting industry.

Mr. Shinn.

TX 643. Knitting Research Credits by arrangement.

Prerequisites: Graduate standing and 8 credits in knitting technology.

Problems of specific interest to the knitting industry will be assigned for study and investigation. The use of experimental methods will be emphasized. Attention will be given to the preparation of reports for publication.

Graduate Staff.

TX 651, 652. Fabric Development and Construction 3-3

Prerequisite: B.S. Degree in Textiles (Weaving and Designing option) or equivalent.



Nelson Textile Building



Fish growth studies using scales.



Research on the biology of the gray squirrel.

Application of advanced technology to the development and construction of woven fabrics. Mr. Whittier.

TX 681. Textile Research

Credits by Arrangement

Problems of specific interest to the textile industry will be assigned for study and investigation. The use of experimental methods will be emphasized. Attention will be given to the preparation of reports for publication. The master's thesis may be based upon the data obtained.

Graduate Staff.

TX 683. Seminar

1 or 1

Discussion of scientific articles of interest to textile industry; review and discussion of student papers and research problems.

Graduate Staff.

TC 605. Physical Chemistry of Dyeing

3 or 3

Prerequisites: CH 422, PY 212, CH 342.

Dyeing is treated as physico-chemical process emphasizing equilibria, kinetics, and practical aspects of research into dyeing processes.

Mr. Cates.

TC 606. Chemistry of Fiber-Forming High Polymeric Systems

3 or 3

Prerequisite Courses: CH 422, PY 212, CH 342.

The course will embody studies of the mechanism and kinetics of polymerization, the properties and behavior of high-polymer solutions, the mechanical behavior of natural and synthetic fibrous materials as related to molecular structure.

Mr. Cates.

DEPARTMENT OF ZOOLOGY

Graduate Faculty

Professors: FREDERICK SCHENCK BARKALOW, JR., Head, BARTHOLOMEW BRANDNER BRANDT (Emeritus), DANIEL SWARTWOOD GROSCH, REINARD HARKEMA, THOMAS LAVELLE QUAY.

Associate Professor: WILLIAM WALTON HASSLER.

Assistant Professor: JOHN A. SANTOLUCITO.

The Master of Science and the Doctor of Philosophy degrees are offered in Animal Ecology and Wildlife Biology. Graduate programs leading to advanced degrees in Animal Parasitology and other fields of Zoology can be arranged in cooperation with the Department of Zoology of the University of North Carolina at Chapel Hill.

The new O. Max Gardner Biological Laboratories building has excellent facilities for training and research. The classrooms and laboratories are furnished with modern equipment. Spacious graduate student offices are available as well as a number of well-equipped research laboratories which provide space for graduate students' investigations. Excellent library facilities are provided for advanced study in the special areas of Zoology in which graduate degrees are offered.

Accommodations are provided for the well-curated teaching collections of fish, reptiles and amphibians. A large bird and mammal range adequate

to contain an estimated 25,000 specimens is on the same floor as the wild-life teaching laboratory. Comparison collections are available for food habits research studies on all native game animals.

Excellent facilities for life history and ecologic studies are available in the field of animal parasitology. A large autopsy and specimen preparation laboratory is housed in an adjacent building, which also includes an aquarium room, small mammal room, and dermestid room.

A number of farm ponds ranging in size from two to seven acres are located on the state lands near Raleigh and are available for farm pond research studies. Several experimental nursery pools are located adjacent to Gardner Hall, and additional facilities near Fayetteville have been made available through a cooperative program with the North Carolina Wildlife Resources Commission.

Equipment and facilities are available for undertaking graduate problems in marine and estuarine fisheries.

A wide variety of positions are open to students holding advanced degrees in Animal Ecology and Wildlife Biology. There is particular need for young men with training in parasitology and related subjects. While the various state game and fish departments, United States Fish and Wildlife Service, United States Forest Service, United States Soil Conservation Service, United States National Parks Service, and other state and land use departments employ the majority of graduates, an increasing number of teaching positions in these fields are available. There are, moreover, more vacancies currently available for qualified individuals than can be adequately filled. It appears that this condition will prevail for at least several more years.

Courses for Advanced Undergraduates

- ZO 452. Animal Microtechnique 0-3
Prerequisites: ZO 103, and CH 203.
The theory and practice of preparing temporary and permanent histological mounts for microscopic study. Mr. Harkema.

Courses for Graduates and Advanced Undergraduates

- ZO 501. Ornithology 0-3
Prerequisite: ZO 103.
The biology and classification of birds. Field trips for the study and identification of local forms, including trips to Lake Mattamuskeet in February and the coast in May. Individual research projects on nesting populations. Mr. Quay.

- ZO 513. Advanced Animal Physiology I 3-0
Prerequisite: ZO 301.

The comparative physiology of selected systems. Topics will be chosen for detailed consideration in lectures, collateral reading, and class discussion. Each student will, in addition, prepare a term report. A few topics for study may be determined by the interests of the students and by their needs as may be expressed by the supervisor of their major work. Mr. Santolucito.

- ZO 520. Fishery Science** 3-0
 Prerequisites: ZO 103 and approval of the instructor.
 This course is intended as an introduction to the principles and methods of fishery science. Current theories and practices of fish management will be studied. Life history and biology of important game and commercial species. Survey of fishery resources. Mr. Hassler.
- ZO 521. Fishery Science** 0-3
 Prerequisites: ZO 520 and ST 311.
 An analysis of fishery research methods and objectives. Detailed studies of the procedures for estimating fish populations, annual reproduction, mortality rates, growth rates, and exploitation rates. The relationship between natural fluctuations in fisheries and environmental factors. Mr. Hassler.
- ZO 522. Animal Ecology** 0-3
 Prerequisites: ZO 103 and BO 103.
 The interrelations of animals and their environments—land fresh water, marine. Mr. Quay.
- *ZO 532 (GN 532). Biological Effects of Radiations** 0-3
 Prerequisites: ZO 103 and approval of instructor.
 Recommended Correlatives: GN 411, ZO 301, and BO 421.
 Qualitative and quantitative effects of radiations (other than the visible spectrum) on biological systems, to include both morphological and physiological aspects in a consideration of genetics, cytology, histology, and morphogenesis. Mr. Grosch.
- ZO 541. Cold-blooded Vertebrates (Ichthyology)** 0-3
 Prerequisite: ZO 103.
 The classification and ecology of selected groups of fishes. Lectures, laboratories, and field trips dealing with the systematic positions, life histories, interrelationships, and distribution of the particular groups of fishes selected in accordance with the needs and interests of the class. Mr. Hassler.
- ***ZO 542. Cold-blooded Vertebrates (Herpetology)** 0-3
 Prerequisite: ZO 103.
 The classification and ecology of selected groups of amphibians and reptiles. Lectures, laboratories, and field trips dealing with the systematic positions, life histories, interrelationships, and distribution of the particular groups of amphibians and reptiles selected in accordance with the needs and interests of the class. Mr. Hassler.
- ZO 544. Mammalogy** 3-0
 Prerequisites: ZO 103, ZO 223, and approval of instructor.
 The classification, identification, and ecology of the major mammalian groups. Mr. Barkalow.
- ***ZO 545. Histology** 0-4
 Prerequisite: ZO 103.
 The microscopic anatomy of animal tissues. Mr. Roberts.

ZO 551, 552. Wildlife Science 3-3

Prerequisite: ZO 206.

The principles of wildlife management and their application are studied in the laboratory and in the field. Designed primarily for seniors majoring in Wildlife Biology. Mr. Barkalow.

***ZO 561. Animal Embryology** 0-4

Prerequisite: ZO 103.

The study of fundamental principles which apply in the achievement of complex animal structure, including both invertebrate and vertebrate materials. Correlative laboratory study to provide training in the basic disciplines and techniques. This course is intended for advanced students in entomology, animal industry, poultry science, and zoology.

Mr. Roberts.

ZO 571. Special Studies Credits by Arrangement

Prerequisites: ZO 103 and approval of the instructor.

A directed individual investigation of a particular problem in Zoology, accompanied by a review of the pertinent literature. A maximum of three credits allowed toward the bachelor's degree, six toward the master's degree, and nine toward the doctorate. Graduate Staff.

******ZO 591. Parasitology I** 4-0

Prerequisites: ZO 103 and 223.

The study of the morphology, biology, and control of the parasitic protozoa and helminths of man, domestic and wild animals.

Mr. Harkema.

***ZO 592. (ENT. 582). Parasitology II. (Medical Entomology)** 0-3

Prerequisite: ENT 301 or 312.

A study of the morphology, biology and control of the parasitic arthropods of man, domestic and wild animals. Mr. Harkems.

Courses for Graduates Only

ZO 603. Advanced Parasitology 0-3

Prerequisites: ZO 591 and 592.

The study of the theoretical and practical aspects of parasitism; taxonomy, physiology, and immunology of animal parasites.

Mr. Harkema.

ZO 614. Advanced Animal Physiology II 3-0

Prerequisites: ZO 301, and approval of the instructor.

Selected fundamental principles in physiology will be studied and interpreted for their relation to the vertebrates. Lectures and critical reports to promote acquaintance with general literature and recent advances. Lectures, discussions, written and oral reports. Mr. Santolucito.

ZO 622. Seminar 1-1

The presentation and defense of current literature papers dealing either

* Spring 1960
**** Fall 1961

with the findings of original research or with fundamental biological concepts. Graduate Staff.

***ZO 627. Zoogeography

3-0

Prerequisites: ZO 522, and approval of instructor.

The geographic distribution of animals—land, fresh water, marine.
Mr. Quay.

ZO 641. Research in Zoology

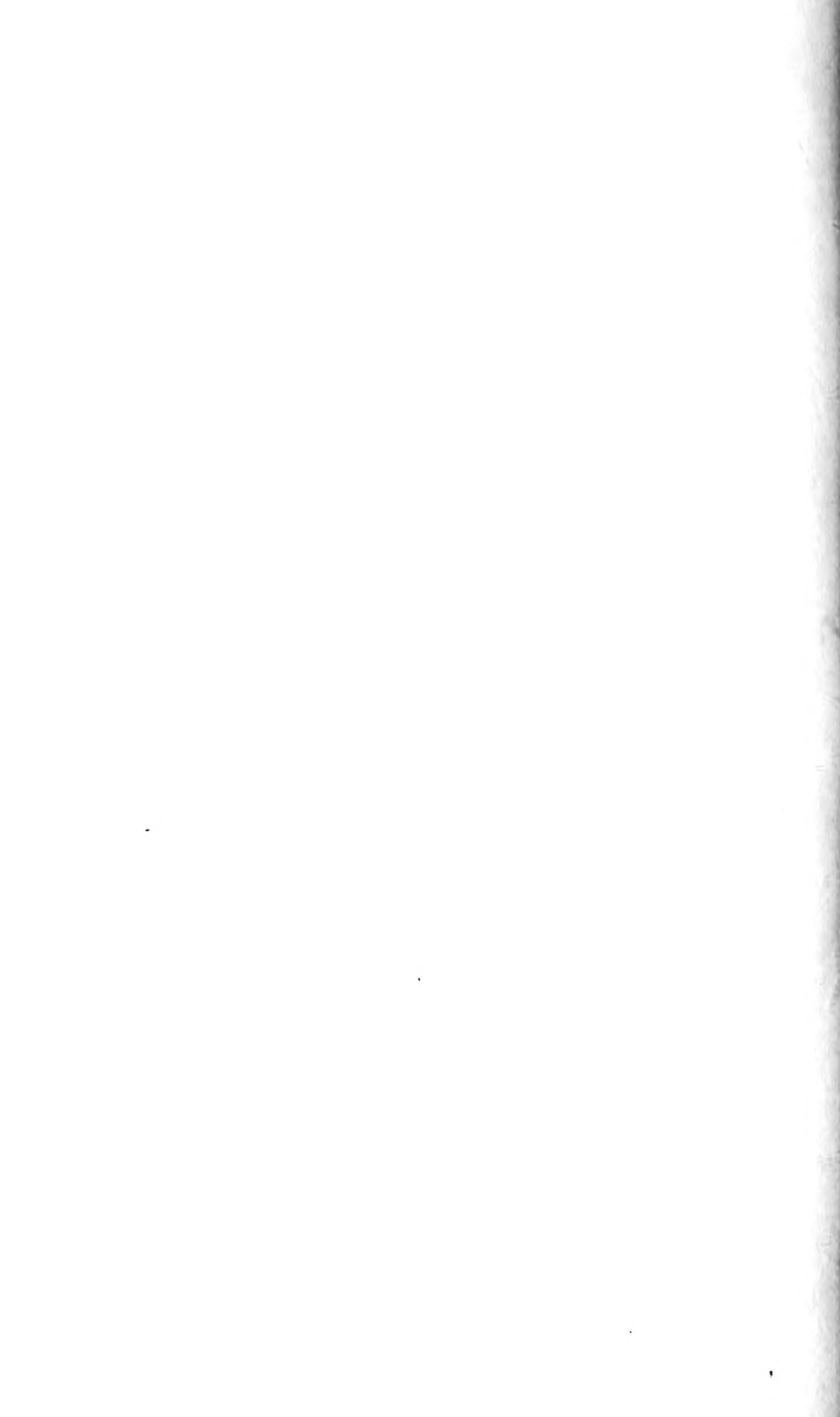
Credits by arrangement

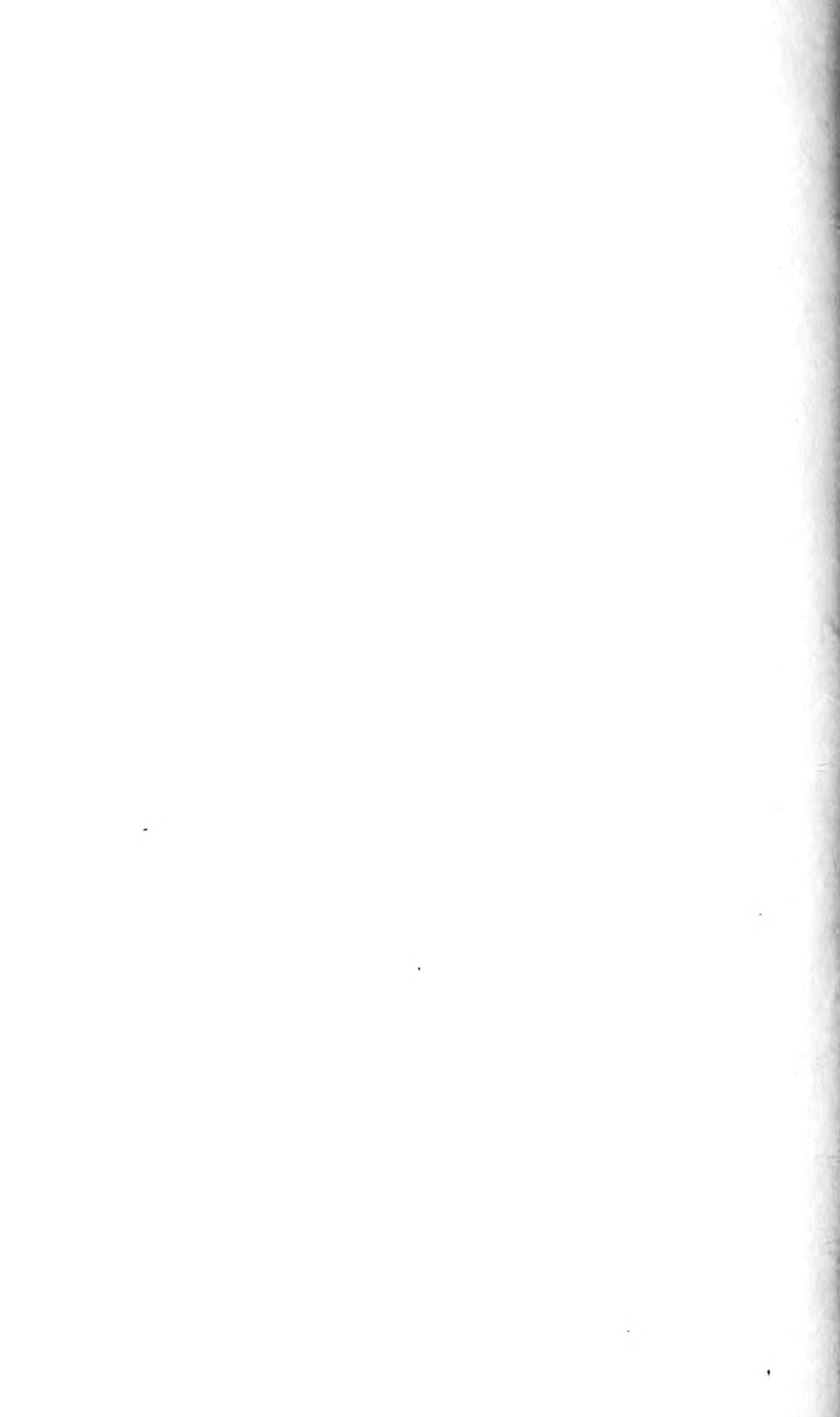
Prerequisites: Twelve semester credits in Zoology, and approval of the instructor.

Problems in development, life history, morphology, physiology, ecology, game management, taxonomy, or parasitology. A maximum of six credits is allowed toward the master's degree, but any number toward the doctorate
Graduate Staff.

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